DOCUMENT RESUME

ED 359 063 SE 053 532

AUTHOR	Sheldon, Daniel S., Ed.; Penick, John E., Ed.
TITLE	Favorite Labs from Outstanding Teachers. Monograph VII.
INSTITUTION	National Association of Biology Teachers, Washington, D.C.
REPORT NO	ISBN-0-941212-10-6
PUB DATE	91
NOTE	96p.; Compiled from recipients of NABT's Outstanding Biology Teacher Award.
AVAILABLE FROM	National Association of Biology Teachers, 11250 Roger Bacon Drive #19, Reston, VA 22090.
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Anatomy; *Biology; Classification; Cytology; Genetics; High Schools; Ichthyology; Newsletters; Ornithology; Physiology; *Science Activities; Science and Society; Science Experiments; *Science Instruction; Science Laboratories; Science Materials; Science Projects; Secondary School Science; Secondary School Teachers; Teaching Methods; Technical Writing

ABSTRACT

This monograph is the first attempt to collect and share some of the teaching techniques, activities, and ideas of former recipients of the Outstanding Biology Teacher Award. The lessons are organized into topical themes to facilitate their incorporation into standard curriculum. The manual is divided into two main sections, "Labs" and "Ideas." The section on labs contains descriptions in lesson form of 16 laboratories grouped within the following chapters: (1) "Science Technology Society"; (2) "Taxonomy"; (3) "Ecology"; (4) "Anatomy & Physiology"; and (5) "Cytology." In the section "Ideas," nine ideas are grouped within the following chapters: (1) "Quick Alternatives"; (2) "Student Projects"; and (3) "Newsletters." (PR)

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Favorite Labs from Outstanding Teachers

Monograph VII

compiled from recipients of NABT's Outstanding Biology Teacher Award

Favorite Labs from Outstanding Teachers

Monograph VII

Editors
Daniel S. Sheldon
John E. Penick
University of Iowa
Iowa City, Iowa

compiled from recipients of NABT's Outstanding Biology Teacher Award

National Association of Biology Teachers
1991

Published by the National Association of Biology Teachers
11250 Roger Bacon Drive #19, Reston, Virginia 22090

ISBN 0-941212-10-6

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Cover photo by William F. McComas.

Printed at The Sheridan Press, Hanover, Pennsylvania.

The Outstanding Biology Teacher Award program

The National Association of Biology Teachers each year recognizes outstanding biology teachers in each of 53 states, territories and the District of Columbia for excellence in life science education. The Outstanding Biology Teacher Award, given annually since 1961, recognizes the highest standards of achievement in the biology teaching profession. For the last 30 years NABT has rewarded more than 1,000 teachers for their valuable contributions to both the profession and their students.

This monograph is our first attempt to collect and share some of the teaching techniques, activities and ideas of former OBTA recipients. The ideas and activities outlined here were contributed by past award winners and illustrate the innovative skills and excellent pedagogical and content knowledge of some of this country's premier teachers.

The editors have attempted to organize these exemplary investigations into topical themes to facilitate their incorporation into standard curriculum. By doing so we hope this monograph becomes a valuable resource for teachers in their continuing efforts to enrich the classroom experience of students.

Several of these lessons involve techniques or chemicals that can be dangerous if mishandled. Please be sure you and your students follow safe laboratory procedures at all times. Read the procedures carefully and consult state or local safety manuals or textbooks for additional information. NABT advises teachers to consult with their local school district before using blood in the classroom and before doing any activity involving human subjects to see if parental permission is required.

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John E. Penick began his teaching career at Jackson High School in Miami, Florida. Since moving to Iowa (for the weather), John's focus has turned to teacher education. Now John teaches the science methods course, directs the secondary teacher education program and administers the Science Education Center. John was NABT president in 1989, has won two NSTA OHAUS awards for innovative college science teaching and was named Outstanding Science Educator of the Year by AETS in 1987. While Dan is on his sailboat, John is usually in an airplane (sometimes his own), pursuing his interests in international education and languages.

Acknowledgments

Obviously, without the inspiration (and perspiration) of many outstanding biology teachers, innovative laboratory activities would not exist. But, the authors of this volume went a step further (like all exemplary teachers) and submitted them to us for public scrutiny. Even with these trials, they stuck with us. As a result, we would like to personally thank our 25 particularly dedicated authors who had the patience to work with us as we wrestled with issues of selection, design, format and production.

An equal partner in our task was, as always, our award-winning secretary, Sharon Metzler, without whom we would probably accomplish little and remember nothing.

We would also like to thank Michelle Robbins for her marvelous sense of design and willingness to spend many hours on this book. We also recognize and appreciate Patricia McWethy and the other NABT staff for seeing this project through to completion.

We needed all of your help and we got it. We appreciate your efforts sincerely.

Daniel S. Sheldon
John E. Penick
Editors

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CHAPTER 1. SCIENCE TECHNOLOGY SOCIETY

An Affective/Cognitive Strategy for Teaching Huntington's Disease

INTRODUCTION

The life of Woodie Guthrie and his death from the disease Huntington's chorea is a good way to put a human face on cold genetic facts. Songs such as *This Land Is Your Land* and *Lonesome Valley* are familiar to students, and they empathize with the struggle waged by Guthrie, one of the disease's most famous victims.

Huntington's chorea, or Huntington's disease, is a ravaging and deadly condition inherited as an autosomal dominant. It has variable expressivity, which means that everyone with the gene will get the disease but not all to the same degree. Facial expressions become distorted; head and hands appear to writhe in constant motion. The first symptoms occur when victims are in their thirties or forties, when they may already have passed the gene on to the next generation. Death occurs in five to fifteen years.

It is assumed that students have already been introduced to Mendelian genetics and autosomal dominant inheritance as well as to a decision-making model. This strategy is directed toward high school students of all levels.

OBJECTIVES

1. Students explain what is meant by Huntington's disease, list its symptoms and use a decision-making model to analyze a bioethical question relating to the disease.
2. Students investigate the principles of genetics and their application.

MATERIALS

information on the Guthrie family
background information on Huntington's disease
recordings of some of Woody Guthrie's songs
audiovisual materials

PROCEDURE: TEACHER

BEFORE LAB

1. Play a recording of *This Land Is Your Land* and assign students to learn all they can about Woody Guthrie, his life and death. Assign a day for them to relate that information.
2. Find audiovisual on symptoms of Huntington's disease (see Resources).

DAY OF LAB

1. Play a Woody Guthrie song while taking roll.
2. Find out what students know about Woody Guthrie, and write their contributions in a master list on the board or on an overhead.
3. Present a short lecture on Huntington's disease: its cause, onset and consequences, including actual phenotypic expression and how it affects childbearing. Show audiovisual, if available, on symptoms.

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NORTH CAROLINA, 1982
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4. Turn off the overhead or cover the board. Give students five minutes to write down what they now know about Huntington's disease. After the time has elapsed, ask a few students to read their comments or ask students specific questions.
5. Uncover the board or turn on the overhead and ask students to check their lists against the master list, adding information they forgot.

Procedure: Students

1. Review the following genotype and figure out the probability of a child of this cross inheriting Huntington's disease;

   Hh X hh

2. Working in small groups, discuss the following material from Butterfield, *Values and Biology* (p. 52):

   "Huntington's Disease is a serious nerve condition that results in loss of muscle coordination. It is due to a dominant gene that does not usually express itself until the person reaches adulthood. Anyone whose parent (either father or mother) has Huntington's Disease has a 50 percent chance of developing the disease. In a recent study of more than one thousand people, 23 percent of those who ran a high risk of producing a child with Huntington's Disease said they would not want a prenatal diagnosis even if a test for the disease were available. Why might these people refuse prenatal diagnosis?"

3. Come up with eight reasons for refusing prenatal diagnosis. Rank the reasons from 1 (the one the group most agrees with) to 8 (the reason the group least agrees with). One person from the group will report ideas and rankings to the class.
4. Homework assignment: "Your mother has just been diagnosed as having Huntington's disease. Do you want to know if you carry the gene?" Discuss this problem with your parents. List five reasons why you might answer yes and five why you might answer no. Which answer do you most closely agree with and why?

Helpful Hints

This exercise could be a good lead-in to genetic markers.

References

Television

Hunt, T., Weber, J. (Producers, directors) & Jehlin, A. (Producer, Nova). 1989. *NOVA: Confronting the Killer Gene* [video]. Boston: WGBH.

Sawyer, D. (interviewer) & Bernstein, J. (Producer). (1989, Spring). *60 Minutes: The Hardest Choice*[television series]. New York: CBS.

Recordings

Recordings of Woody Guthrie songs.

Books

Edward, R. (1979). *Woody Guthrie and me.* Berkeley: Lancaster-Miller Publishers.

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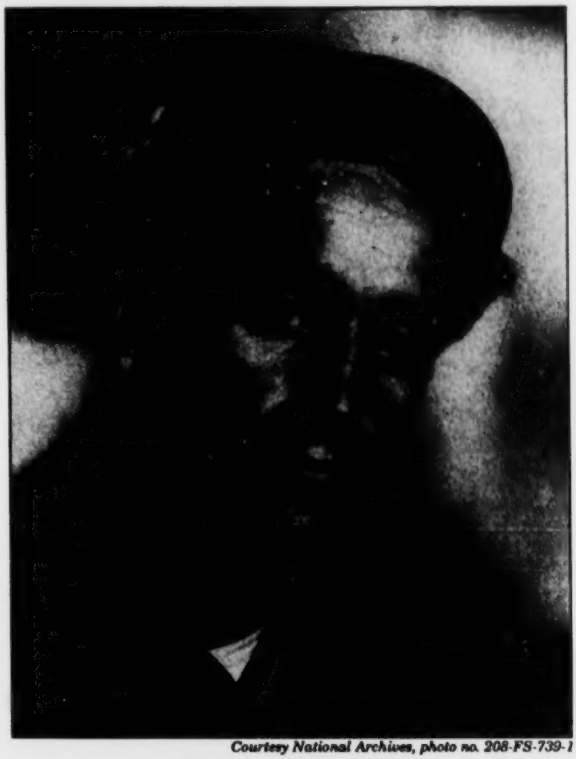
This lab is based on a lesson plan written by Carolyn P. Hammond and Mary B. Boldon, Maryville High School, Maryville, TN; Dwight G. Brown, Bountiful High School, Bountiful, UT; Elizabeth Burck, Kenai Central High School, Kenai, AK; Jim Dixon, Garinger High Schoool, Charlotte, NC; and Karen A. Griest, Bryan Station High School, Lexington, KY.

The Life & Death of Woody Guthrie



Courtesy National Archives, photo no. 208-FS-739-1

WOODY GUTHRIE

Woodrow Wilson "Woody" Guthrie was born July 14, 1912, in Okemah, Oklahoma. He was the second of five children born to Charlie and Nora Bell Guthrie.

Woody's early years in Okemah seemed to have a strong influence on his later life. His father's involvement in local politics was a source of education, although related discussions frequently led to arguments. Several family tragedies, including a house fire and a sibling death, occurred during those early years.

Probably the most significant tragedy of Woody's teens was the mental and physical deterioration and subsequent death of his mother. The onset of her illness began in 1918 when Woody was only six. Her unusual behavior, which included forgetfulness, aimless wanderings, temper tantrums and unsteadiness, led to her institutionalization in June of 1927. A year later she was diagnosed as having Huntington's chorea. Nora died in 1929. When Woody was asked later if he was afraid of getting the disease, he emphatically stated, "There's no way I'm gonna get that disease." (Robbin 1979).

Following his mother's death, Woody seemed to take on a nomadic life. This was also the time that the United States entered the Great Depression. To earn money, Woody would work in migrant camps. This introduced him to the unemployed and impoverished. Both his songs and political philosophy reflected the empathy he felt for these people. Many of the more than 1000 songs he wrote dramatized the injustices and hardships these people suffered.

Woody was married twice and had seven children. It was not until May of 1952, at the age of 40, that he exhibited the first signs of a serious illness. As his wife Marjorie described the incident, "Woody had a violent outburst and foamed at the mouth." He was hospitalized for three weeks and misdiagnosed as possibly being schizophrenic or alcoholic.

Because the problems continued, he was hospitalized three months later.

The doctors decribed him as being thin and scrawny, looking somewhat older than his 40 years. He was extremely fidgety and his movements were jerky, random and purposeless. His speech was hesitant with many jerky pauses. His mental capacity did not seem to be affected. Huntington's disease was mentioned but ignored, and Woody attributed his problem to alcoholism.

In September of 1956 the definitive diagnosis of Huntington's chorea was made by a neurologist. From then until his death in 1967 he deteriorated steadily. His appetite increased although he continued to lose weight because his constant spastic movements burned more energy than he could produce. His body grew frail, his bones brittle and his system vulnerable to disease. His senses became so dulled that he often burned himself with a cigarette without noticing. He stopped speaking entirely. At the time of his death, he weighed less than 100 pounds. His skin was waxy and translucent and his bones stuck out. Toward the end he was too weak to even shake.

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Klein, J. (1980). *Woody Guthrie: A life.* New York: Alfred A. Knopf.

Robbin, E. (1979). *Woody Guthrie and me.* Berkeley, CA: Lancaster Miller.

Woody Guthrie Song List

Partial list of songs recorded by Woody Guthrie. Those marked with a * were also written by him.

Ain't A-Gonna Do
All You Facists Bound to Lose
All Work Together
At My Window
Ballad of Chanukan
Ballad of Isaac Woodward
Ballad of Pretty Boy Floyd
* *Belle Star*
Been in Jail
* *Better World*
* *Biggest Thing That Man Has Ever Done*
Billy the Kid
Blowin' Down This Road
Boomtown Bill
Brand New Situation
Bubble My Gum
Build a House
Business Ain't Dead
Car Song
Chain Around My Leg
Chinese and the Japs
Clean-O
Come See
Cowboy's Philosophy
Curly Headed Baby
Dance Around
Dead from the Dust
* *Dead or Alive*
* *Dear Mrs. Roosevelt*
* *Deportees*
Don't Push Me
Do Re Mi
Dust Bowl Refugee
Dust Can't Kill Me
Dust Pneumonia Blues
Dusty Old Dust
Dry Bed
* *The Dying Miner*
* *East Texas Red*
Electricity and All
* *End of My Line*
Go and Leave Me
* *God Blessed America*
Going Down the Road
* *Goodnight Little Arlo*
Good Old Union Feeling
Gotta Get to Boston
* *Grand Coulee Dam*
Great Dust Storm
* *Great Historical Bum*
Greenback Dollar
Grow Grow Grow Grass Grass Grass
* *Gypsy Dave*
* *Hangout Slipknot*
* *Hard Ain't it Hard*
* *Hard Travelin'*
Here Comes Woody and Lefty Lou
Highway 66
Hooverville
How Di Do
I Ain't Got No Home in This World Anymore
I Don't Feel at Home in the Bowery No More
I'll Eat You, I'll Drink You
I'll Spell You a Word
I Just Want to Sing Your Name
I'm A-Goin' Back to the Farm
I'm A-Takin' It Easy
* *I'm Living in Coney Island 'till I Die*
It Takes a Married Man to Sing a Worried Song
* *I've Got to Know*
* *Jackhammer Blues*
* *Jackhammer John*
* *Jesus Christ*
Jig Along
Joe Hillstrom
The Jolly Banker
* *The Ladies Auxiliary*
Lonesome Valley
Ludlow Massacre
* *Mail Myself to You*
Make a Bubble
Matthew Kimes
Merry Go 'Round
Miss Pavilichenko
Moneyless Children
More Pretty Girls than One
More War News
The Mound of Your Grave
* *My Daddy*
My Dolly
My Little Seed
My Uniform's My Dirty Overhalls
My Wild Woman
Needle Song
* *Nineteen Thirteen Massacre*
* *New Found Land*
* *New York Town*
* *Oklahoma Hills*
Old Army Mule
On My Way
1, 2, 3, 4, 5, 6, 7, 8
* *Pastures of Plenty*
* *The Philadelphia Lawyer*
Pick It Up
Put Your Finger in the Air
Race You Down the Mountain
* *Ramblin' 'Round*
Rattle My Rattle
The Relativity Song
* *The Sinking of the Ruben James*
Riding in My Car
* *Riding on the City of New Orleans*
The Rio Grande Valley
* *Roll Columbia*
Sacco's Letter to His Son
* *Sally Don't You Grieve*
Sharecropper Song
Sleepy Eyes
Stackabones Own Song
Stepstone
Swimmy Swim
* *Taking It Easy*
* *Talking Columbia*
Talking Dust Blues
* *Talking Hard Luck Blues*
* *Talking Hitler's Head Off Blues*
* *Talking Sailor*
Talking Subway Blues
This World is Not My Home
This Land Is Your Land
Tom Joad
Turkey in the Corn
Union Burying Ground
* *Union Maid*
Union's My Religion
Vigilante Man
Wake Up
We All Work Together
When I Get Home
When You're Down and Out
Wish-y Wash Wash
Who's My Pretty Baby
Why Do You Stand There in the Rain
Why Oh Why
* *Willy Rogers Highway*
* *You Gotta Go Down and Join the Union*
You Low Life Son of a Bitch
You're on the Last Go 'Round
You Souls of Boston

CHAPTER 1. SCIENCE TECHNOLOGY SOCIETY

Biological Clues

INTRODUCTION

This lab is designed to demonstrate the physical uniqueness of each person, to explain the usefulness of genetic markers and to present students with some bioethical problems. The lab is divided into two parts; the crime lab section should be completed first. The Alzheimer's disease clues section can be used to introduce bioethical decision-making using genetic problems.

OBJECTIVES

1. In Part I, students experience scientific research in an enjoyable way.
2. In Part II, students learn about Alzheimer's disease and consider some bioethical issues related to it.

PART I: CRIME LAB

MATERIALS

(PER LAB TEAM OF 2 OR 3 STUDENTS)

microscope
6 slides
6 coverslips
pipet

(FOR THE FOLLOWING STAINS YOU NEED ONLY 1 OR 2 DROPPING BOTTLES PER CLASS SET UP ON A "MATERIALS" TABLE)

Benedict's solution
biuret solution
Lugol's iodine
Sudan I stain
package of clues from each "suspect" (see list under Procedure: Teacher)
8 test tubes (2 for each biochemical test: 1 experimental and 1 control)
test tube holder
test tube brush
beaker of boiling water on a hot plate for the class
transparent tape (1 roll per class)
index cards (1 or 2 5x7 cards per student)

PROCEDURE: TEACHER

BEFORE LAB

1. Come up with a "crime" for students to investigate; any story can be used to start students thinking about how they will carry out their investigation. Tell them that someone has been stealing cafeteria food in order to cater a party; school officials are worried about the sanity of the criminal and about the health of the party attendees.
2. The week before the lab, collect from each student:
   - a few strands of hair (making sure each piece is about the same length to make the problem harder)
   - a few threads from his/her shirt or sweater (from the inside seam so no one complains)
   - a copy of his/her fingerprints (done with a soft pencil and transparent tape). Have each student rub a soft #2 pencil across an index card, making a very dark area. The students then roll their fingertips across the dark area, covering their fingerprints with

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Judith Ann Dayner
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graphite from the pencil. Have them carefully press a piece of clear transparent tape onto their fingertips and then onto an index card. Raised prints will be clearly seen on the card under the tape. The students should label each print with correct hand and finger (thumb, first or pinky, second or ring).

- a piece of black paper containing a section of his/her footprint. Have each student step on a piece of black construction paper with the toe area of his/her shoe. The shoe should leave a dusty print. Have students wear this same pair of shoes the day of the lab.

3. On clean microscope slides, make two types of "blood" slides: On some smear your blood and on the others smear red dye or ketchup. If the use of blood is a problem, obtain prepared slides of blood smears and remove the label. These can be used for this lab each year. The red dye slides can be made permanent with balsam or by using clear nail polish to attach the coverslip to the slide.
4. After the slides are dry, place either a blood slide or a dye slide in each plastic bag along with the other clues. Also place containers with various clues into each plastic bag. Fill a separate bag for each suspect on the student's Suspect List. See Crime Lab Solutions for a list of what to put in each bag.

Other Clues

sucrose
starch
dry protein (egg albumen)
oil (in small vials)
dirt
sand
parts of leaves
tiny insects
minerals
scales from fish
scales from snakes
hairs from dogs or cats
pebbles

Crime Lab Solutions: Suspects & Clues

(this list is for the teacher only)

1. **flour**-baker; **sucrose**-diet; **scales**-snake; **pebbles**-pet; **blood slide**-cut himself
2. **rocks**-geologist; **dog hair**-pet; **starch**-diet; **oil**-chips; **slide with red dye**-paint
3. **scales**-snake; **blood slide**-bites her; **protein**-diet; **pieces of plants**-botanist; **sucrose**-candy she eats; **talcum powder**-she uses
4. **sand**-job; **slide with red dye**-job; **scales**-snake; **starch and sucrose**-diet; **powder**-for snake
5. **oil**-diet; **slide with red dye**-painter; **fish scales**-fish pet; **starch**-diet; **slide with blood**-cuts himself
6. **eraser rubbings**-job; **cat hair**-pet; **slide with blood**-cat bites; **protein and oil**-food for cat
7. **dirt**-gravedigger; **cat hair**-pet; **starch**-diet; **protein and oil**-lunch; **powder**-for hands; **slide with blood**-hands hurt
8. **dirt**-job; **scales**-pet; **glucose**-pet; **slide with blood**-cuts; **powder**-for hands; **protein, starch and oil**-lunch
9. **sand**-job; **dog hair**-pet; **slide with red dye**-paint; **starch and protein**-pet food
10. **dirt**-job; **rock**-pet; **sucrose and starch**-diet; **slide with red dye**-paint

Make up enough bags so that each lab group gets one. Students can work in groups of two or three. The list of clues depends on the suspect list and on the imagination of the teacher!

5. Once all the clues are in the correct plastic bag, give each suspect a number that corresponds to one of the plastic bags. Each lab group gets a numbered bag and the lab begins. (The bag that each group gets points to a different suspect. Each group will come up with a different solution.)

Students should have previously done Benedict's, Biuret, Lugol's iodine and Sudan I tests. This lab could be used as a follow-up learning experience in which students can apply their previous knowledge of biochemical tests to a different situation. It is a good idea to have instructions on procedures for the four tests posted somewhere in the room for students who need to review them.

Day of Lab

1. Set up boiling water baths around the room for students.
2. Insist on correct lab technique with goggles and lab coats required.
3. Explain to students that because the microscope enables scientists to see details that ordinarily could not be seen, it is an essential tool for criminal investigations. Many mysteries have been solved by discovering some detail, a detail that becomes evidence proving a person's guilt or innocence. Tell them they will be testing their skills as a criminal researcher, since their goal is to find the criminal. They will have to run through several microscopic and chemical tests to determine usefulness of clues "found at the scene" but fortunately saved by their teacher. (Tell them that each group will have a different answer.)
4. Give each team a Suspect List. You can expand the list so that there are as many suspects as there are students in your class. You can also change the suspects' names to those of your students.

Procedure, Part I: Students

1. Work in groups of two or three.
2. Choose an envelope of clues linking one of your classmates to a horrendous crime – that of stealing cafeteria food to cater a party!
3. Determine how to proceed knowing you must identify hair samples, animal fur from pets, cloth fibers from clothing, whether or not blood was found at the scene, clues involving the workplace of the suspect, fingerprint information, footprint information and clues involving food found on the suspect.

When your lab team has determined the identity of the subject from your clues, one team member should approach the "suspect" for questioning concerning what clothing he/she wore on the day of the crime. The "suspect" should donate a piece of hair, have his/her fingerprints taken and be asked to give a footprint on a piece of construction paper. Your team should analyze the artifacts from the suspect and compare them to the clues found at the crime scene. When your team has made a decision, the police officer in charge should be notified (or your teacher if the officer is not present). If your team is correct, the suspect will be charged with the crime (and you're on your way to a high grade). If your team is incorrect, you must continue your study until the perpetrator of the crime is determined.

If you have forgotten how to do any of the food tests, check the posted instructions. Don't forget to use control tubes for each test.

You must keep accurate records of all tests done during the time period.

Crime Lab Suspects

1. **Rob** is a baker, and on his day off he often eats sugary foods. He owns a pet that hisses, and he often cuts his hands on pebbles in his pet's tank.

2. **Elizabeth**'s dog Lassie follows her around in her work as a geologist for the government. When asked about her favorite food, she answered, "Anything starchy, especially potato chips." Yesterday she painted Lassie's doghouse his favorite color – fire engine red!

3. **Steph** has a reptile pet that always bites her and gets lost in her experiments (she's a botanist). She is on a high protein diet, but occasionally gorges herself on Gummy Bears. Powder is important to Steph since her hands must be soft and smooth.

4. **Jenn** has always loved the sea, so oceanography is her field. Strangely enough, on her newly painted boat she keeps a hissing pet, Cuddles, who feasts on bread and jelly. Cuddles loves powder, so Jenny rubs it on him daily.

5. **Joshua** usually has salads for lunch with lots of vinegar and OIL. He cleans and paints the offices where Tricia works. You should see his pet Pisces Furry join him in starchy snacks! Due to his dangerous job, he often cuts himself.

6. **Tricia** can type 232 words per minute (a universe record). The only time she has trouble maintaining this record is when her cat Scrounge walks across the keys and bites her. She throws him a piece of chicken (she is constantly eating fried chicken), and he leaves growling.

7. **Jeremy** has an unusual job – a grave digger! He owns a cat named, of course, "Freshly Dug" and eats starchy foods. He and Brad ate at a fast food hamburger place today, so our spies told us. Grave diggers meet after their shift to tell stories and powder their hands.

8. **Brad** works with Jeremy at the graveyard, planting flowers. He feeds his goldfish Rex glucose water every day after work. Due to his backbreaking labor, Brad always has bruised and bleeding hands. He uses powder on his hands to make them feel better.

9. **Ralph** can walk the deck of any ship in a hurricane, but his *Canis* "Salty Dog" always hides under the freshly painted bunk in a storm. Ralph tempts his pup with pretzels or breadsticks loaded with peanut butter.

10. **Zak** insists that everyone who enters his nursery talk to his pet rock Griswold. Zak recently painted the fence around the nursery red. He eats sugar on crackers for a snack and sometimes even feeds them to Griswold!

Make careful drawings and observations on a "crime sheet" to be handed in to the acting police officer in charge (in this case, your teacher).

Helpful Hints

Have students write a paragraph of analysis explaining how each clue was used in solving the crime puzzle.

Have them write an additional paragraph giving their reasons for choosing the name of the criminal.

Part II: Alzheimer's Disease Clues

Materials

fingerprint charts (1 per student)
index cards (1 or 2 per student)
#2 pencil per student
transparent tape (1 roll per class)

Procedure: Teacher

1. Request from your local police station copies of police fingerprint charts for students to use. Charts may also be purchased from biological supply houses. Many high school biology lab books contain these charts as well. [One such book is *Basic Genetics: A Human Approach* (1983), Dubuque, IA: Kendall-Hunt Publishing Co. ©BSCS.]
2. Explain the term "genetic marker" to students so they understand how geneticists use such markers in genetic counseling. Also explain that not all persons with genetic markers show the symptoms or phenotype of the problem the marker suggests.

Procedure, Part II: Students

Background Information

Our fingerprints have four basic patterns:

- arches, which reach across the finger
- whorls, which circle on the finger surface
- ulnar loops, which open toward the pinky
- radial loops, which open toward the thumb

A study done by Herman Weinreb in 1983 suggested that Down's syndrome and Alzheimer's disease have a common genetic link. He found that a great many Down's syndrome patients and Alzheimer's disease victims show similar fingerprint patterns of eight to 10 fingers with ulnar loops. An abundance of ulnar loops (on eight or more fingers) might be a genetic marker for Alzheimer's disease. This hypothesis has not been widely tested as yet, and further genetic research may support or reject this theory.

Alzheimer's disease is a gradual, irreversible erosion of brain cells that control thought and memory. The first symptom of the disease usually is a difficulty in remembering simple things; victims regress to an infantlike state, needing round-the-clock attention. Alzheimer's affects from 1.2 million to 4 million Americans overall; between 5 and 15 percent of all Americans over 65 are affected by it. Most people with Down's syndrome, if they live long enough, have Alzheimer's disease by age 40.

Data

(STUDENTS WORK ALONE IF THIS PART OF THE LAB IS DONE SEPARATELY; STUDENTS WORK IN GROUPS OF 2 OR 3 IF THIS PART OF THE LAB IS DONE ON THE "SUSPECT'S" PRINTS.)

1. Take prints of your 10 fingers on an index card or use your "suspect's" prints. Label each finger as left/right and as pinky, thumb, ring, index or

middle finger. If using suspect's fingerprints, check each of the 10 fingers. Under each fingerprint, record the type of pattern for that finger.

2. Count the number of ridges on your left ring finger. Write the number under the print for that finger.
3. Attach index card containing fingerprints to the lab questions.

Questions

1. Count the number of ulnar loops on your fingers and determine if you (or your suspect) are at an increased risk for this genetic disease.
2. If a person had 10 fingers with ulnar loops, would this person definitely develop Alzheimer's? Explain your answer. (See information under Procedure, Part II: Students.)
3. What is a genetic marker? What is it in this lab?

Ethics Questions

1. If you owned a company, should you have the right to check a person's genetic health record? Explain.
2. If you found that a person had a genetic marker for a degenerative disease, should you have the right not to hire that person even if he/she did not show any indication of the disease at the time? Explain your answer.

Personalize the Problem

Physicians today can test people for some genetic diseases using genetic markers. Some people who are in "at risk" families refuse to be tested. If you were in such a family, would you be willing to be tested? Explain your answer.

Summing Up

Review lab with students, pointing out that this link between Down's syndrome and Alzheimer's is not proven. Student fears over their own risks for genetic diseases should be discussed; this lab should help students personalize what "having a risk for a genetic disease" really means.

CHAPTER 1. SCIENCE TECHNOLOGY SOCIETY

Teaching Biology Around Themes

INTRODUCTION

Too often biology is taught as a collection of fascinating but unrelated topics. While teachers should continue to teach their favorite topics, they should consider teaching them around unifying themes. I personally use three themes:

1. The cell theory
2. DNA
3. Evolution

This article will focus on the use of DNA as a central theme in biology.

Teaching around themes does not require a radical restructuring of the curriculum. The main thing I do differently from most standard curricula is teach enzymes and DNA very early in the course. I teach them as two consecutive units and constantly refer to those units during the course of the year. After introductory units on the cell and atomic structure, I begin biochemistry with a discussion of proteins and enzymes.

OBJECTIVES

1. To teach students how the proteins made by a cell determine the properties of the cell.
2. To illustrate to students how the proteins a cell makes are determined by the DNA of the cell.
3. To illustrate to students how changes in DNA can result in changes in proteins made by the cell, with resulting phenotypic changes to the cell.

MATERIALS

Genetic Code (Figure 1)
Amino Acid Structures (Figure 2)
DNA Dry Labs 1 & 2

PROCEDURE: TEACHER

DAY OF LAB

Establish these main points:

1. Proteins are large molecules made up of smaller molecules called amino acids.
2. Many proteins in the cell function as enzymes.

   Emphasize that in cells, reactions would not occur unless their activation energy was lowered by an enzyme. Therefore, the enzymes found in a cell determine which reactions will occur in the cell.

   It is important to give examples of reactions which occur in cells. The richer your list, and the more lively your discussion of these reactions and their real, observable consequences (i.e. brunettes have an enzyme that deposits melanin in their hair; blondes do not), the more student involvement you will have.
3. There is a different enzyme for every reaction that occurs in the cell. If a particular enzyme is not present, or is

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changed, the reaction for which it is responsible will not happen.

4. Enzymes have a three-dimensional structure that is determined entirely by the order of amino acids in the protein. Remind students that enzymes are proteins and discuss the primary, secondary and tertiary structure of proteins.

   Explain to students that this is how enzymes would look to you if you were small enough to walk around inside a cell. A twisted slinky is an effective visual. The important point is that the tertiary structure of a protein (i.e. the unique lumps and bumps) is determined entirely by the order of amino acids in the protein. Emphasize that even though a protein may be composed of hundreds of amino acids, if even one amino acid is wrong, the whole protein might not fold right and the reaction it is responsible for would not occur. Sickle cell anemia can be used as an example. If one amino acid in the whole hemoglobin molecule is wrong, the hemoglobin does not fold right, does not dissolve properly and does not carry oxygen efficiently; sickle cell anemia results.

5. Discuss a lock and key model of enzyme action, emphasizing the importance of the active site as the place on the enzyme where the reaction occurs. Since the substrate has to fit into the active site, if the protein has not folded properly the active site could be the wrong shape and would no longer hold the substrate.

   Once students understand that the enzymes in a cell determine which reactions will occur in the cell and that the properties of an enzyme are determined by the order of amino acids in the protein, they are ready to know what determines the order of amino acids in proteins. This makes a perfect introduction to DNA.

   Introduce DNA as the molecule found in chromosomes that contains inherited information by determining the order to amino acids in proteins. From this, it is easy to define genetic information as information that tells the cell which proteins to make and therefore determines which reactions will occur in a cell. That's why we're different from amoebas. Our chromosomes contain different DNA so we make different proteins, and different chemical reactions occur in our cells. This is why sickle cell anemia is an inherited disease. The person's hemoglobin contains one wrong amino acid because a mistake in his or her DNA codes for a wrong amino acid in the protein hemoglobin.

   The discussion of DNA can be straightforward. It is a large molecule made of smaller molecules called nucleotides. There are four different nucleotides in DNA and the order of nucleotides in DNA determines the order of amino acids in proteins. Discuss the details of protein synthesis and the role of RNA. Give them a copy of the Genetic Code (Figure 1) and a DNA Dry Lab in which they have to go from DNA to RNA to protein.

PROCEDURE: STUDENTS

Review the following vocabulary list:

Enzyme
: A protein that lowers the activation energy required for a reaction and is not changed by the reaction.

Primary structure
: The order of amino acids in the protein.

Secondary structure
: The amino acid chain coils up on itself to form an alpha-helix (like a coiled telephone wire with the R groups sticking out).

Tertiary structure: The alpha helix folds up on itself, forming a compact, roughly spherical structure with unique lumps and bumps.

6. Complete the DNA Dry Lab(s).

Helpful Hints

One of the nice things about teaching a protein-DNA unit like this at the beginning of the course is that it comes up again and again during the year. Some examples follow:

1. Discuss mutation as a change in DNA. This is why things that damage DNA such as ultraviolet light, radiation, X-rays and some chemicals can cause birth defects if they occur in eggs and sperm and are passed to future generations. And, mutations in somatic cells can alter the proteins produced in those cells and cause cancer.
2. Genetic diseases are easily understood as changes in DNA which resulted in a wrong protein. Some examples:
   a) Hemophilia is due to a mistake in the DNA that codes for a protein needed to make blood clot.
   b) PKU is due to a mistake in the DNA that codes for a protein needed to break down the amino acid phenylalanine.
   c) Tay-Sachs disease is due to a mistake in the DNA that codes for a protein needed to break down lipids.
   d) Cystic fibrosis is due to a mistake in the DNA that codes for a protein that is involved in regulation of chloride channels in the cell membrane.
3. During cell respiration, discuss fermentations. When our muscles run out of oxygen, we produce lactic acid. Some bacteria and yeast produce alcohol and carbon dioxide while other bacteria and yeast produce vinegar and carbon dioxide. These differences occur because the DNA of the different organisms codes for different enzymes, and these enzymes do different things with the pyruvic acid and $NADH_2$.
4. A thorough discussion of mutation helps students understand the concept of variation when we discuss evolution. Concepts such as camouflage and warning coloration tie into the study of DNA. How did the viceroy butterfly come to resemble the monarch butterfly even though the two are not closely related phylogenetically? Evidently, there was a random mutation in some viceroy butterfly which caused it to make an enzyme which gave it orange wings with black spots. That individual then survived because of its resemblance to the monarch.

First base	Second base: U	Second base: C	Second base: A	Second base: G	Third base
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met or Start	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

From Campbell, N. (1990). Biology (2nd ed.). Reprinted with permission of Benjamin/Cummings Publishing Co.

Figure 1. The genetic code of messenger RNA bases.

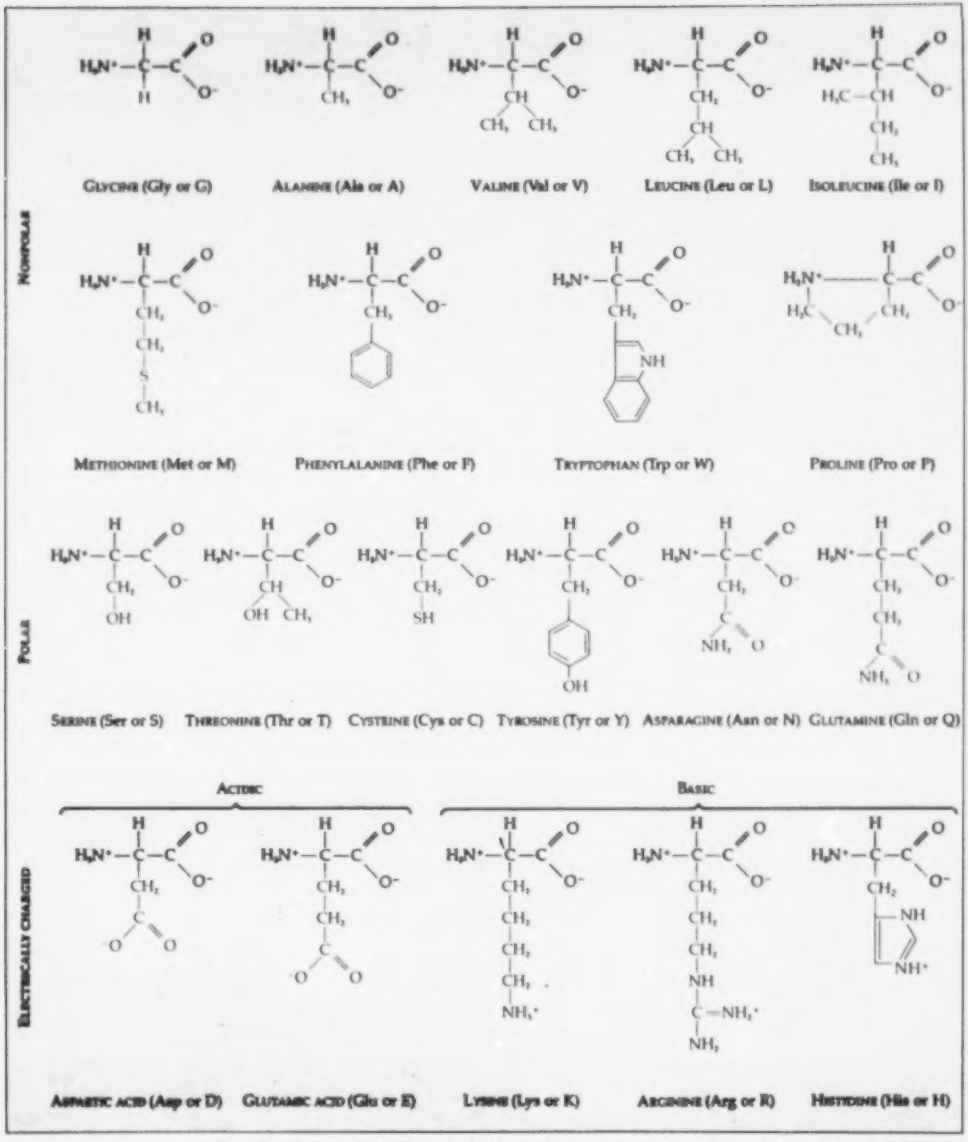

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Figure 2. The 20 amino acids.

Dry Lab 1

The following is the base sequence on one strand of a DNA molecule:

A A T G C C A G T G G T T C G C A C

1. Give the base sequence of the complementary DNA strand.

2. Draw this DNA molecule.

3. Give the base sequence of the strand of mRNA read from the original DNA strand.

4. Draw this RNA molecule.

5. What protein fragment would this mRNA code for?

6. If the fourth nucleotide in the original DNA strand were changed from G to C, what would the resulting mRNA look like?

7. What is the sequence of amino acids?

8. If a G were *added* to the original DNA strand after the third nucleotide, what would the resulting mRNA look like?

9. What would the resulting protein look like?

10. If the eighth nucleotide in the original DNA strand were changed from G to C, what would the resulting mRNA look like?

11. What would the resulting protein look like?

Dry Lab 1: **Answers**

The following is the base sequence on one strand of a DNA molecule:

A A T G C C A G T G G T T C G C A C

1. Give the base sequence of the complementary DNA strand.

   T T A C G G T C A C C A A G C G T S

2. Draw this DNA molecule.

3. Give the base sequence of the strand of mRNA read from the original DNA strand.

   U U A C G G U C A C C A A G C G U G

4. Draw this RNA molecule.

5. What protein fragment would this mRNA code for?

   leucine arginine serine proline serine valine

6. If the fourth nucleotide in the original DNA strand were changed from G to C, what would the resulting mRNA look like?

   U U A G C G G U C A C C A A G C G U G

7. What is the sequence of amino acids?

   leucine glycine serine proline serine valine

8. If a G were *added* to the original DNA strand after the third nucleotide, what would the resulting mRNA look like?

   U U A G C G G U C A C C A A G C G U G

9. What would the resulting protein look like?

   leucine alanine valine threonine lysine arginine

10. If the eighth nucleotide in the original DNA strand were changed from G to C, what would the resulting mRNA look like?

    U U A C G G U G A C C A A G C G U G

11. What would the resulting protein look like?

    leucine arginine

Dry Lab 2

The following is the base sequence on one strand of DNA:

C A C G T G G G A C T G A G G A C T C C T C

1. What is the sequence of bases on the complementary DNA strand?

2. What mRNA would be read from the original DNA strand?

3. What protein fragment would this mRNA code for?

4. Draw this protein. For extra credit, indicate the charges on the amino acids.

5. If the 17th nucleotide in the original DNA strand were changed from T to A, what mRNA would the new DNA code for?

6. What protein would this mRNA code for?

7. Draw this protein. For extra credit, indicate the charges on the amino acids.

8. How are the proteins in #4 and #7 different?

Dry Lab 2: **Answers**

The following is the base sequence on one strand of DNA:

C A C G T G G G A C T G A G G A C T C C T C

1. What is the sequence of bases on the complementary DNA strand?

   G T G C A C C T G A C T C C T G A G G A G

2. What mRNA would be read from the original DNA strand?

   G U G C A C C U G A C U C C U G A G G A G

3. What protein fragment would this mRNA code for?

   valine histidine leucine threonine proline glutamic acid glutamic acid

4. Draw this protein. For extra credit, indicate the charges on the amino acids.

5. If the 17th nucleotide in the original DNA strand were changed from T to A, what mRNA would the new DNA code for?

   G U G C A C C U G A C U C C U G U G G A G

6. What protein would this mRNA code for?

   valine histidine leucine threonine proline valine glutamic acid

7. Draw this protein. For extra credit, indicate the charges on the amino acids.

8. How are the proteins in #4 and #7 different?

   In the protein in #4, the sixth amino acid is glutamic acid. In the protein in #6, the sixth amino acid is valine. The change of a single base in DNA has resulted in one different amino acid in the protein. This is the mutation responsible for sickle cell anemia. The DNA in question #1 codes for the first seven amino acids of the beta chain of hemoglobin. The mutation shown in question #5 codes for the beta chain of hemoglobin in people with sickle cell anemia.

   Notice that glutamic acid has a negative charge, whereas valine is a nonpolar amino acid. This means that normal hemoglobin is more negatively charged than sickle cell hemoglobin. This results in sickle cell hemoglobin being less soluble in water than normal hemoglobin. This reduced solubility of sickle cell hemoglobin in water is believed to result in the symptoms of sickle cell anemia.

CHAPTER 1. SCIENCE TECHNOLOGY SOCIETY

Classroom Debate: Are Viruses Living Organisms?

INTRODUCTION

The primary goal of any laboratory science course is to present students an environment for self-discovery by means of hands-on scientific methodology. In some cases direct discovery may be limited by the availability of technological equipment or the vast scope of the area in question. A powerful alternative learning strategy is the use of formal debate as opposed to the informal discussion typical of normal class analysis of data.

Students entering a first year biology course are introduced to the basic characteristics of life, including cell theory. Texts are usually written in simplistic, hard and fast format in dealing with these life characteristics. Viruses, which do not exhibit cell structure, usually are discussed in microbiology studies some time later in a course. Their impact on our world–from AIDS to cancer–is so powerful that it warrants at least several days of study, but the high school laboratory offers little for students to work with. A formal debate can successfully teach the paradox of viruses through the question: Are viruses living organisms?

OBJECTIVES

1. Students will hone preparation and outside research skills in order to make a convincing and well-organized presentation.
2. Students will cooperate with team members, divide labor, improve communication skills, enhance critical thinking skills and their ability to refine an argument, and learn to "think on their feet."

PROCEDURE: TEACHER

BEFORE LAB

1. The debate itself and the procedures leading up to it can take up to five days.
2. **Suggested for Day 1:**
   Discuss virus background, including history, characteristics and the impact on the biosphere.
3. **Suggested for Day 2:**
   Present a lab that views electron micrographs of bacteriophages, tobacco mosaic virus, etc. The emphasis should be on observation skills and inquiry techniques. The outcomes of this exercise should include specific knowledge of virus structure and life cycles, lytic and lysogenic infection.
4. **Suggested for Day 3:**
   Introduce the debate question – Are Viruses Living Organisms? Distribute and discuss student handout on guidelines and procedures (Figure 1). When preparing for the debate, it is important that students derive available resources on their own as much as possible. This should include textbooks, journals, library resources, interviews with faculty, college instructors, research scientists, physicians, veterinarians, nurses, etc.

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ARIZONA, 1988
John Michael Trimble
Corona del Sol High School
1001 East Knox Road
Tempe, AZ 85284

5. Divide the class into two teams: pro and con. Ask the teams to begin their research inside and outside of the classroom.
6. **Suggested for Day 4:**
   Teams prepare for debate (see Procedure: Students)

Day of Lab

7. **Suggested for Day 5:**
   Review debate format, answer any last minute questions and let students begin.

Procedure: Students

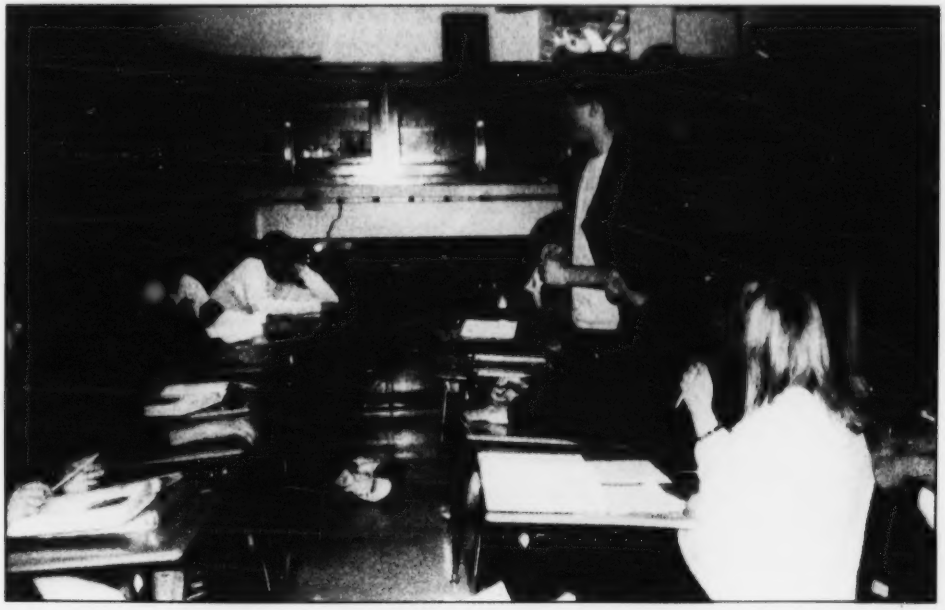
See Student Worksheet

Helpful Hints

Continue to stress strong participation by all students, particularly those who are more shy and reserved. Students tend to enjoy role-playing, so any props or professional attire help add credibility and believability to their case. This activity arouses their competitive instincts in a fun and socially meaningful way.

Summing Up

Some classes will derive exceptional benefits from this exercise, particularly when community resources are fully tapped. An appreciation for science and the transient nature of knowledge, as well as insight into personal perspective and our sense of reality (clinical vs. academic, etc.), matures students' view of the world and their role in it.



STUDENT WORKSHEET

NAME _____

PERIOD _____

Are Viruses Living Organisms?

A Classroom Debate

INTRODUCTION

From class discussion and lab activities you are now familiar with basic virus form and function, means of reproduction and their dependent relationship with other organisms. Are these features consistent with basic characteristics of life discussed earlier in the year? Are viruses living organisms? You will formally debate this question with your peers after your team has completed more research.

PROCEDURE

1. The class will be divided into two teams, pro and con. You are on the _____ team.
2. Arrange seating so that you and your team members are together.
3. Study the debate format below:

Debate Format

I. **Pro:** *Opening Statement* (5 min.)
II. **Con:** *Response* (2 min.)
III. **Con:** *Opening Statement* (5 min.)
IV. **Pro:** *Response* (2 min.)
V. **Con:** *Counterpoint* (3 min.)
VI. **Pro:** *Counterpoint* (3 min.)
VII. **Con:** *Closing Argument* (5 min.)
VIII. **Pro:** *Closing Argument* (5 min.)

Follow-up discussion and teacher input.

Assignment of position paper to be completed by each student.

Please note that within your time limit you may rotate speakers as you choose. All students on the team should participate in both the research and the debate.

4. How will your team prepare for the debate? What resources are available for you to use today in class and within the community over the next 48 hours? Brainstorm with other members of your group.
5. Begin working as a team in dividing the research labor into specific tasks. Organize each member's responsibility in gathering background information. Please remember all references must have complete bibliographies.
6. The debate will take place the day after tomorrow; therefore, tomorrow will be devoted to strategy. Share what you've learned with the other members of your team. Decide how you plan to present your argument and make assignments for each team member. Rehearse and discuss possible opposition strategies.
7. During the debate, make sure you have a visible role in the activity. Remember that listening, reflecting and responding are key elements to successful debate.

Your team will be graded by the criteria listed below. Your team's effectiveness will be determined by every team member doing his/her very best.

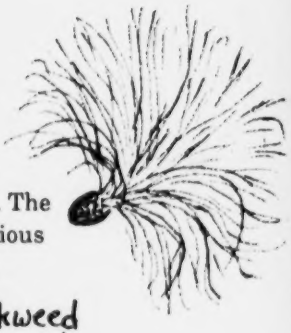
8. Your grade will be determined by:
   a. Evidence of preparation: your notes and documented references (complete bibliography).
   b. Perceived involvement in team preparation and participation of debate.
   c. A position paper based on your personal thoughts after the entire research and debate process has taken place.

EVALUATION CRITERIA	1	2	3	4	5
Full Team Participation + Cooperation					
Preparation + Organization					
Strength of Arguments					
Documented Evidence Provided					
Adaptability to Opposing Team					
Creativity in Presentation					

TOTAL _____

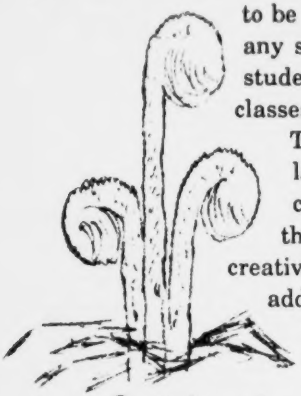
CHAPTER 2. TAXONOMY

Biology Scavenger Hunt


milkweed seed

INTRODUCTION

A scavenger hunt is an excellent way to end the year and review some of the principles of a biology course. To find some of the items on the list, students will have to know something about various species' habitats and life cycles, as well as the obvious classification. The teacher provides jars, bags, nets, etc. for collecting, as well as the various references needed for identification. It is important to show students any poisonous plants, such as poison ivy, so they will not pick them! Make sure the area in which students are going to be collecting is safe and warn them of any safety problems such as ravines or traffic hazards. Caution students to be quiet around school buildings so as not to disturb other classes.


fern fiddleheads

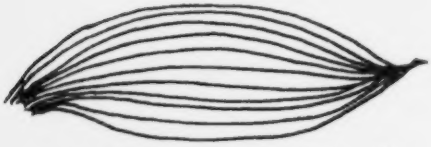
The list in Table 1 was designed for northern New England in late May. Vertebrate species were purposely omitted to simplify capture and release problems. Including items such as "something soft" or "something white" allows students to be somewhat creative. The last item (unusual item; not found by another team) was added after several classes had completed this exercise and found some unusual items that were not on the list (i.e. a molted snakeskin). The time allowed for the activity (this is often weather dependent) and the number of members on a team should be determined by the teacher.

OBJECTIVES

1. A scavenger hunt allows students to apply many of the biological principles they've learned.

MATERIALS

jars
paper lunch bags
sealable plastic bags (recycled yearly)
nets
gloves
plant, animal, fungi keys or Golden Nature Guides


parallel-veined leaf

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VERMONT, 1975
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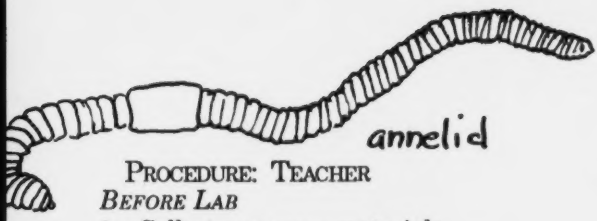
52 Institute Road
Burlington, VT 05401



Procedure: Teacher

Before Lab

1. Collect necessary materials.
2. Prepare appropriate list of items to be found (see Table 1). Helpful Hints has information on point determination.
3. Do safety check of collection area (can also be done the day of the lab).
4. Prepare list of safety items/cautions for students.
5. Warn students to dress appropriately for the exercise (especially relative to shoes).

Day of Lab

1. Warn students that some items should be handled indirectly (with tools or gloves).

Procedure: Students

1. Collect as many as possible of the items listed in Table 1 within the given time limit. Plant and fungi materials should be collected with as little disturbance to the environment as possible. Do not pick the *only one of anything!* Live animal specimens should be collected only if they can be returned safely and without damage to them.

2. Submit the items for verification; your team must identify each item. You will have only one chance for each item on the list. For example, if you submit a pinnately-veined leaf for a parallel-veined one, you will receive a score of zero for the pinnately-veined leaf.
3. Correctly identifying the species by scientific name will double the score for that item. You will have to prove to the instructor that you have correctly identified any organism. If you identify the item incorrectly, you will not have another chance to double the points, but you will receive the allotted points for the item.
4. The team accumulating the most points will automatically have the maximum score; all other teams will receive scores based on that figure. Scores will be converted to a letter grade (top grade = A+; all others, a percentage of that) and may have to be adjusted to reflect the number of team members.

Helpful Hints

1. The points listed in Table 1 were determined by the relative ease or difficulty of finding the item or by the information needed by the team to know what they were looking for. None of the words used on the list was defined for students during this exercise, but they were all words which had been used during the previous months of the course.
2. If two consecutive classes are using this exercise, many of the teams will arrange to do some searching as homework. This is not discouraged.
3. This exercise can be more formally structured (for example, into cooperative learning groups) if the teacher wishes.

Summing Up

I have found this exercise to be an excellent way to end the year. The students have a chance to use some of their accumulated knowledge and apply it directly to their own environment. I refine the lab from year to year to reflect changes in the course, the environment or the level of the students.

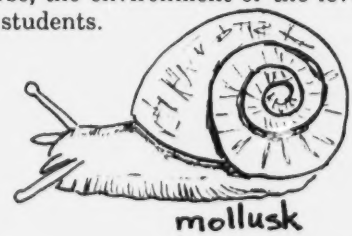
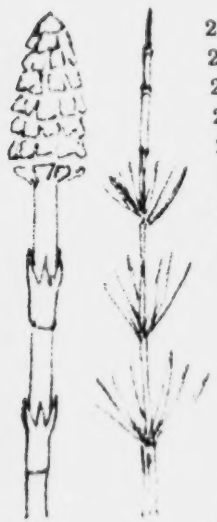


Table 1. Scavenger hunt list.

ITEM FOUND	POINT VALUE
1. a feather	1
2. one seed dispersed by wind	1
3. two different seeds dispersed by animals	2
4. exactly 100 of something *	3
5. a palmately-veined leaf	1
6. a pinnately-veined leaf	1
7. a parallel-veined leaf	1
8. a thorn	2
9. one camouflaged insect	3
10. a moss gametophyte	1
11. a moss sporophyte	2
12. a fern fiddlehead	4
13. a fern sporophyte	1
14. a horsetail	2
15. a second species of horsetail	5
16. something round *	2
17. part of an egg (not chicken)	3
18. something fuzzy *	1
19. a piece of fur *	3
20. five pieces of human litter (trash)	1
21. something perfectly straight *	2
22. something beautiful *	2
23. a leaf that has been chewed (not by you)	3
24. something that makes noise *	3
25. something white *	1
26. something soft *	2
27. a sun trap *	3
28. an annelid	3
29. a bone (double points if identified)	4
30. an owl pellet	10
31. a crustacean	5
32. an arachnid	2
33. scat *	5
34. a monocot flower	2
35. a dicot flower	2
36. a fungus	1
37. a second species of fungus	3
38. something spherical *	2
39. a beetle	2
40. an insect larva	2
41. a mollusk	3
42. unusual item; not found by another team *	5



horsetails

mushroom

**These items must not be made by humans. They must be from the natural world.*

CHAPTER 2. TAXONOMY

Dichotomous Keys

INTRODUCTION

Dichotomous keys are tools used by biologists to identify biological organisms. They may, however, be written to identify any group of objects in which no two individuals are exactly the same. Having students write keys helps them with observation skills as well as recording and organizing data. This activity was designed to be done at or near the beginning of a new term. Characteristics that could be considered too personal – weight, family income, etc. – cannot be used in the dichotomous key.

OBJECTIVES

1. Students will construct a dichotomous key and be able to make inferences from it.
2. Students will quickly become acquainted with each other, easing cooperative learning strategies.

MATERIALS

None needed

PROCEDURE: TEACHER

1. Find or create a simple dichotomous key for students to use as an example.
2. After students have gathered their data, lead them through a discussion of how to work with it by the process of elimination. Try an example that uses shoes: Have 10 students donate a shoe and the class write a key for them on the board.

PROCEDURE: STUDENTS

1. Write a dichotomous key that will identify any 20 students in your biology class, as well as your teacher.
2. Include on data sheet a list of the characteristics you are using to identify the students.

The following rules must be observed:

- You may not have any more than two choices at any one step of the key.
- Start with general choices and move to more specific ones.
- For each choice, you must either be sent on to another part of the key or end at the name of a person in your class.
- Each student's key must be different and each must work.
- Use the following chart to record the names of the 20 students you will classify and the characteristics used for the classification. **Don't forget to include your teacher in the key.**

HELPFUL HINTS

If you include specific instructions to the students that they must include you as one of their 20 people, it makes it very easy to grade – just see if you key out properly.

OBTA
OREGON, 1982
Kathryn Green
Hillsboro High School
3285 S.W. Rood Bridge Road
Hillsboro, OR 97070

NAMES	CHARACTERISTICS											
	HAIR LENGTH	COLOR HAIR	EYE COLOR	SEX	HEIGHT	SHOE SIZE	BEHAV-IOR	BRACES	GLASSES	AGE	FAV. COLOR	FAV. CLASS
JANE	SHOULDER	BRN/RED	BL	F	5'3	7½	QUIET	NO	NO	15	BLK	SPANISH
JUAN	SHORT	BLK	BRN	M	5'4	9½	QUIET	NO	NO	15	GRN	MATH
DILLON	SHORT	BLONDE	BL	M	5'10	11	LOUD & QUIET	NO	NO	15	BL	MATH
RAMONA	MED.	LT. BRN	BL	F	5'2	9	LOUD & QUIET	NO	NO	15½	GRN	ART
VICKY	LONG	BLK	GRN	F	5'4	6½	LOUD & QUIET	NO	NO	16	BLK	SPANISH
ART	SHORT	BRN	BL	M	5'7	10½	LOUD & QUIET	NO	NO	15	BLK	LUNCH
MARTY	SHORT	DK. BRN	GRN-BL	M	6'½	9½	LOUD & QUIET	NO	NO	15	PURPLE	P.E.
SONYA	MED.	BRN	HAZEL	F	5'7	8	MEDIUM	NO	NO	16	BLK	DON'T HAVE I
MANDY	SHORT	BLK	BRN	F	5'1	7	NICE	NO	NO	15	FOREST GRN	LANG.
LINDA	SHOULDER	BRN	BRN	F	5'8	9	OBNOX-IOUS	NO	NO	15	GRN	SPANISH
KARLA	LONG	BLONDE	GRN	F	5'	6	NICE	NO	NO	16	RED	HISTORY
MARY	SHORT	BRN	BRN	F	5'5	8½	NICE	NO	NO	15	GRN	MATH
MARISA	LONG	BRN	BRN	F	5'6	7	NICE	NO	YES	15	BLK	STUDY HALL
ALLY	LONG	BLONDE/ BRN	BL	F	5'5	9	NICE	NO	YES	15	GRN	TYPING
TEACHER MR. ROGERS	SHORT	BRN	BL	F	5'4	5½	QUIET	NO	YES	OLD	BL	BIOLOGY
BECKA	SHOULDER	BLONDE	BRN	F	5'2	5	NICE	NO	NO	15	GRN	LUNCH
HANNAH	LONG	BRN	BL	F	5'8	9	NICE	NO	NO	15	BL	ACCNT.
AMY	MED.	BLONDE	BL	F	5'7	9	OUTGO-ING	NO	NO	15	PURPLE	PSYCH.
BONNIE	MED.	BRN	BRN	F	5'1	9½	NICE	NO	NO	15	PURPLE & GRN	LUNCH
KATHY	LONG	RED	BRN	F	5'4	8	NICE	NO	NO	16	GRN & BL	DON'T HAVE I

Figure 1a. Dichotomous key done by a 10th grade student.

1a. Teacher ..... Ms. Rogers
1b. Students 2
2a. Males 3
2b. Females 6
3a. Above 6' tall ..... Marty
3b. Below 6' tall 4
4a. Shoe size above 10 5
4b. Shoe size below 10 ..... Juan
5a. Favorite color black ..... Art
5b. Favorite color blue ..... Dillon
6a. Red hair ..... Kathy
6b. Other hair 7
7a. Red brown hair ..... Jane
7b. Other hair 8
8a. Obnoxious behavior ..... Linda
8b. Other behavior 9
9a. Hazel eyes ..... Sonya
9b. Other eyes 10
10a. Favorite class accounting ..... Hannah
10b. Favorite class other 11
11a. Favorite class psychology ..... Amy
11b. Favorite class other 12
12a. Blonde hair 13
12b. Other hair 15
13a. Blue eyes ..... Ally
13b. Other eyes 14
14a. Eyes brown ..... Becka
14b. Eyes green ..... Karla
15a. Black hair 16
15b. Brown hair 17
16a. Long hair ..... Vicky
16b. Short hair ..... Mandy
17a. Light brown hair ..... Ramona
17b. Brown hair 18
18a. Favorite class math ..... Mary
18b. Favorite class other 18
19a. Glasses ..... Marisa
19b. No glasses ..... Bonnie

Figure 1b. Dichotomous key done by a 10th grade student.

CHAPTER 3. ECOLOGY

Owl Pellet Lab

INTRODUCTION

Owls belonging to the order Strigiformes, as well as the carnivorous species of birds, regurgitate the indigestible remains of their prey in the form of an elongated pellet. This is common to owls, gulls, goatsuckers, accipiter hawks, swifts and grouse. Owl pellets usually are the most readily available and the most convenient to use as lab specimens. They show feeding habits and provide small mammal skeletons, most often rodents and occasionally birds. The owl usually swallows its prey whole or nearly so and, as a result, consumes the entire animal. For these birds, the gizzard acts as a trap for the indigestible materials of the prey: fur, feathers, bones, teeth, chiton or nails.

The indigestible materials remain in the gizzard after being squeezed from these remains by the strong muscular action of the gizzard. The formed pellet remains in the gizzard and is regurgitated usually within 12 hours. If the owl has had a good night's feeding, the pellet may contain the remains of several animals. Most pellets are dark gray and average about 3-3 1/2" long and 1-1 1/2" wide.

To collect owl pellets, first look for an owl's nest or roost. This most often will be a barn, abandoned building, rocky outcropping or large tree. As the owls sit on their perch, the pellets are regurgitated, pass through their mouths and drop to the ground below. Collecting owl pellets may be incorporated into a field trip, but because the pellets could carry zoonoses, remember to always follow strict safety precautions. You may prefer to purchase pellets from biological supply houses. They do not contain soft body materials, so are usually odorless. To prevent dermestid beetle activity they can be stored in a freezer or tightly closed container for relatively long periods of time with a small quantity of p-Dichlorobenzene.

OBJECTIVES

1. To dissect an owl pellet and separate skeletal and integument remains.
2. To use skulls from pellets to identify species of organisms in owls' diet.
3. To reconstruct and label the skeleton remains.
4. To use the list of identified species from the entire class to construct the owl's food web.

MATERIALS

owl pellet
fine dissecting forceps
dissecting needle
container for remains
diagram of rodent or bird skeleton
white glue
rigid paper (cardboard, poster board) for mounting skeleton
peroxide (either concentrated 30 percent or commercial 10 percent)

OBTA
OREGON, 1983
Bob Bastian
Klamath Union High School
1300 Monclaire St.
Klamath Falls, OR 97601

Procedure: Teacher

1. Give each student one owl pellet to dissect. You can collect these yourself or get them from a biological supply house.

Procedure: Students

1. Using dissecting tools, remove fur and feathers from bone parts. Be careful not to smash small bones while pulling it apart. Some, such as rib or cranial bones, may have been crushed by the forceful contraction of the gizzard. Periodically discard fur and feathers to keep them from being scattered around the room.
2. After all bones are collected you may wish to bleach them to make them white. If so, place bones in a beaker of peroxide water (concentrated peroxide 30 percent = 1 part to 12 parts water or if you are using commercial peroxide, 10 percent = half and half with water). Leave the bones in the peroxide solution for 24 hours. Then remove bones, rinse with fresh water and allow to air dry or use infrared lamps to produce faster drying and additional bleaching.
3. Assemble like bone parts to see how many organisms are represented in the pellet. (Counting the skulls is usually the easiest way to determine how many were in the pellet.)
4. Identify the various bones by name using a rodent or bird skeletal chart.
5. Using the appropriate chart, reassemble the skeleton by laying it out on a piece of paper corresponding to the chart. If you are constructing a lateral view of the skeleton, it may be necessary to use only one side of paired bones, such as one side of a rib cage or left limbs. It may be necessary to construct a dorsal view of the skeleton with appendages arranged and spread out to the side.
6. Once you have a skeleton assembled, glue it with white glue to the rigid paper.

Helpful Hints

The skeleton(s) or contents of the owl pellet that have been assembled can be used in the following ways:

Comparative anatomy study

Compare these skeletons to other mammals or the human skeleton to see similarities and differences.

Species identification

Identify mammal or bird species found in the immediate area where pellets were collected. Using the skull, identification can be made with a mammal or bird taxonomy key. Rare mammal skulls, such as some shrews and even bats, have been found from time to time in owl pellets.

Species activity

Collecting owl pellets from the same location periodically during the year will

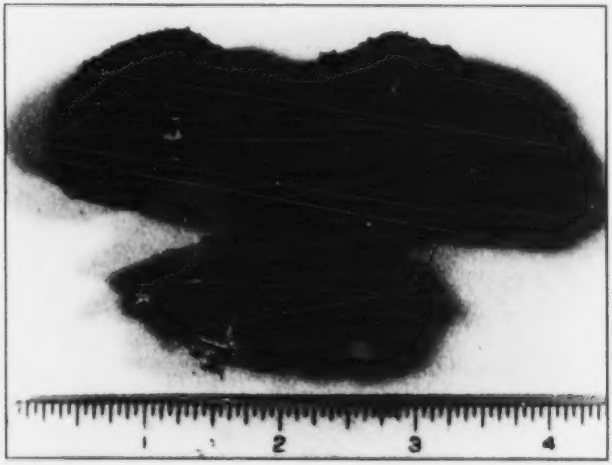


Figure 1. Intact owl pellets.

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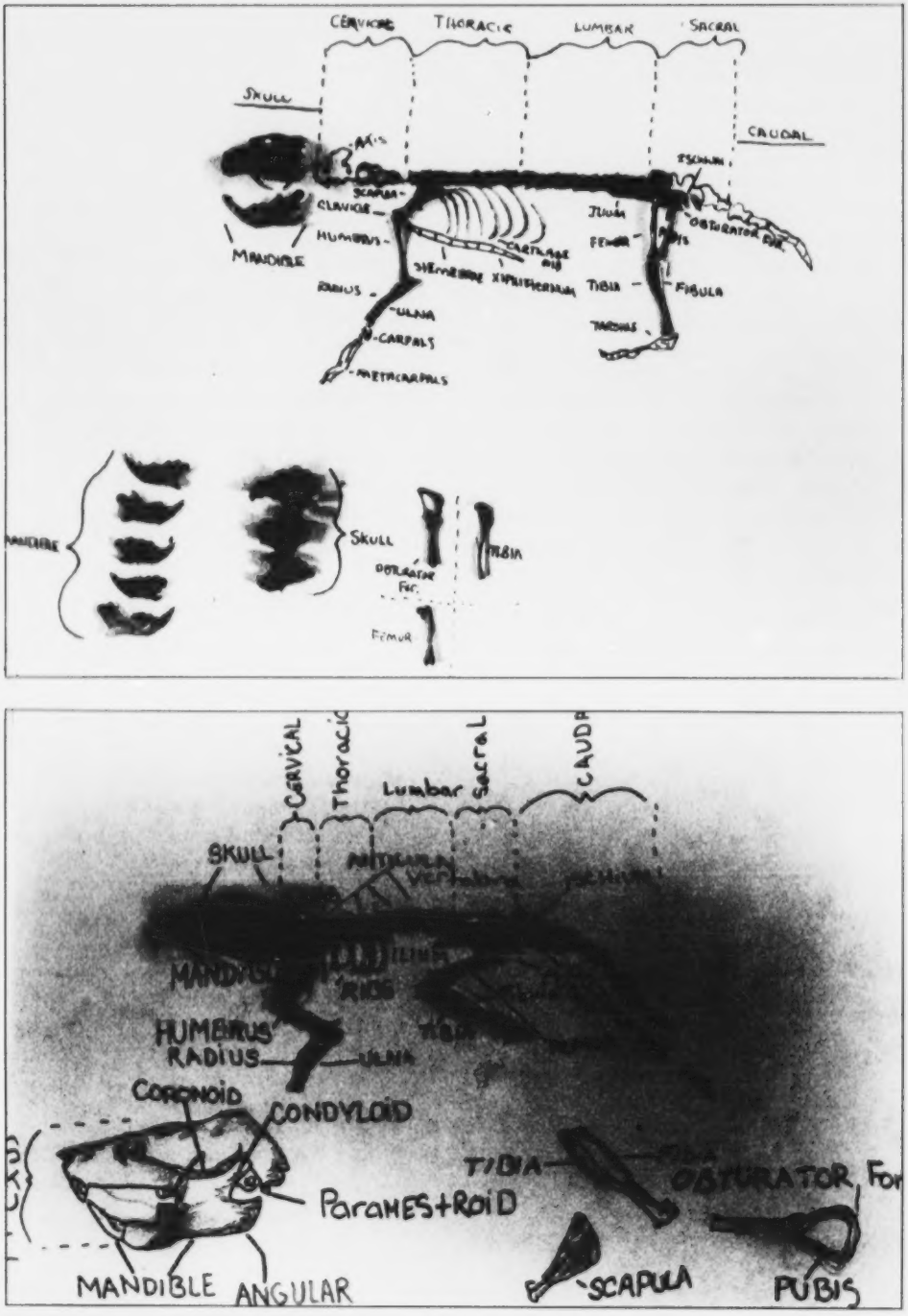

Figures 2 & 3. Contents of individual owl pellets

42

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enable you to identify and make a collection of the mammals found there, especially rodents. By keeping record of the various species from each period, you can construct a pattern of activity for the various rodents throughout the year. Different species will be found to be active during each season or at various times of year.

Understanding owl behavior

You can gain a better understanding of the feeding behaviors and desires of various species of owls by the contents of their pellet. Identifying the owl species may be difficult since they are not seen during the day. Because the owl is at or near the top of a food chain, the chain or food web can be reconstructed using the species of organisms identified from the pellets. A more complete food web can be constructed including what might have been eaten by each of the organisms consumed by the owl.

Summing Up

The constructed skeletons and food webs make a great visual display for the classroom or school. Keep each year's list of species identified by students to compile both seasonal and yearly food webs. This list can be used for future reference and should take into account rare and unusual animals in the owls' diet, such as bats or birds.

CHAPTER 3. ECOLOGY

Cousin's Animal

INTRODUCTION

This exercise will give students an opportunity to use priority ranking skills in making decisions that affect the life of an animal. Through simulation, students will decide what steps should be taken first, second, third and so on to bring a sick animal back to health.

OBJECTIVES

1. Students will learn techniques used in problem solving.
2. Students will learn to arrive at conclusions through group consensus.
3. Students will develop an understanding of morphological, behavioral and environmental criteria used in animal taxonomy.

MATERIALS

Per student:
- priorities list
- official scores list
- pencil
- a picture of a mythical animal of your making

PROCEDURE: TEACHER

BEFORE LAB

1. Draw or create your strange animal on an overhead or poster.

DAY OF LAB

1. Show students your created animal and present them with the following scenerio:

   Your cousin has brought you an unusual animal about the size of a large house cat that he found during a recent trip around the world. Neither of you knows what it is. Your cousin thinks the animal is sick; it is not eating or moving around much. Your cousin must leave on another trip, so you promise to help the animal get well.
2. Pass out Figure 1 to students.
3. Use the Teacher's Scoring Key as answers to C. "Official Score."

PROCEDURE: STUDENTS

Figure 1 lists 14 actions you could choose to take. Some are important and should be done before others. In 10 minutes time, rank the choices from 1-14 in order of importance, with 1 being the most important and 14 the least. Give each statement a number. Record your rankings under Column A, "My Score."

Use these assumptions when making your decisions:

1. You have three days to work with the animal before it becomes seriously ill.
2. You may anesthetize the animal to examine it.
3. Expert advice is not available.
4. The animal is common and well-known in some other parts of the world.

OBTA
FLORIDA, 1987
Ruthie Labno
Seabreeze High School
2700 N. Oleander Avenue
Daytona Beach, FL 32118

After You're Through with Column A

1. Divide into groups of four or five.
2. You will have 20 minutes to employ techniques of group consensus to arrive at a new priorities list. Put your answers in Column E, "My Group's Scoring." Refer to *Decision by Consensus* section.

Decision by Consensus

This is an exercise in group decision-making. Your group is to use group consensus in reaching its decision. This means that the prediction for each of the 14 items must be agreed upon by each group member before it becomes a part of the group decision. Consensus is difficult to reach; not every ranking will meet with everyone's complete approval. Try, as a group, to make each ranking one with which all group members at least partially agree. Here are some guidelines to use in reaching consensus:

1. Avoid conflict-reducing techniques such as majority vote, averaging or trading in reaching decisions.
2. Avoid arguing for your own individual judgments. Approach the task on the basis of logic.
3. Avoid changing your mind only in order to reach agreement and avoid conflict. Support only solutions with which you are able to agree at least somewhat.
4. View differences of opinion as helpful rather than as a hindrance in decision-making.

After You're Through with Column E

1. Ask your teacher for an Official Score sheet and copy it into Column C. These results were obtained from 100 science teachers and scientists who did this activity at a science convention.

After You're Through with Column C

1. Compare your results both individually and as a group by finding the differences in your scores and the official scores. Fill in columns B and D to show the difference and total each separately. This will show you if you were more accurate individually or during group consensus.

	A My Score	B Difference A and C	C Official Score	D Difference E and C	E Group Score
Take its temperature.					
Put it in water to see if it can swim.					
Look it up and read about its natural habitat.					
Check for signs of infection in its mouth.					
Ask your friends what medicine to give it.					
Make a list of the animal's characteristics such as type of teeth, feet, etc.					
Look up and read about the animal's food and water needs.					
Collect some waste droppings to examine.					
Force feed it dog food.					
Adjust temperature and lights to be similar to that found in its natural habitat.					
Compare a list of characteristics with those of other animals.					
Observe the animal.					
Collect a blood sample to examine.					
Offer the animal a drink of water.					

Total: ____of B ____of D

Figure 1. Priorities list.

Teacher's Scoring Key

Suggested ranking of each item and a brief rationale. This was done by a group of 100 scientists who played the game.

8 Take its temperature.
This will indicate whether the temperature is abnormal and may provide information relating to the possible illness.

14 Put it in water to see if it can swim.
Does not provide useful information relating to the possible illness.

5 Look it up and read about its natural habitat.
Provides necessary information so that the animal can be put into a compatible environment.

9 Check for infection in its mouth.
An easily performed action which may quickly provide information related to the possible illness.

13 Ask your friends what medicine you should give it.
Assuming that your friends do not have any expert knowledge, this is probably useless.

3 Make a list of the animal's characteristics such as type of teeth, etc.
Provides information necessary for identification of the animal.

6 Look up and read about the animal's food and water needs.
Provides information necessary to meeting the animal's food and water needs.

10 Collect some waste droppings to examine.
May provide information relating to possible illness.

12 Force feed it dog food.
Probably not useful, may satisfy food requirements.

7 Adjust temperature and lights to be similar to that found in its natural habitat.
Acting on information found in step 4.

4 Compare a list of characteristics with those of other animals.
Provides information for identifying the animal so that its normal characteristics and behaviors can be known.

1 Observe the animal.
Although observation pervades all phases of investigation work, the first step here appears to be observing the animal's characteristics and behaviors. This will make it possible to identify it and detect any abnormalities in characteristics and behaviors.

11 Collect a blood sample to examine.
A more difficult and time-consuming action than actions 8, 9 and 10, but it may provide information relating to the possible illness.

2 Offer the animal a drink of water.
Since adequate water is basic to survival, since it can easily be offered to the animal and be available while other actions are performed and since there is no reason to assume that water would have an adverse effect, this step should not be delayed.

CHAPTER 3. ECOLOGY

Schooling Behavior & Fish

INTRODUCTION

This lab investigates fish swimming together in a school to answer why some fish live in societies. Many animals show grouping behaviors during at least part of their lives, but some fish school consistently, even in an aquarium, and so they are among the best examples for use in a lab study of social organization. A fish school is defined as a group that stays together because group members show positive social responses to each other. A group of fish who come together to feed and then go their separate ways when the food is gone do not form a true school.

Conspecifics are members of the same species. Two lab partners are conspecifics; humans and cats are of different species and are heterospecifics. Have students form small groups to discuss other types of animal behavior.

OBJECTIVES

Upon completion of this lab students will be able to:

1. Perform an experiment examining factors contributing to grouping behavior in fish schools.
2. Construct tables using quantitative records of responses shown by a test organism.
3. Discuss the fact that some fish will school only with their own species and some with other species.
4. Discuss what factors would make a fish choose to travel with a large school. A small school.

MATERIALS

2 15-gallon aquaria
2 4-liter screw top jars
wax pencil
fish net (small)
stopwatch
8-10 of any two of the following species:
Zebra fish (*Brachydanio rerio*)
Harlequin fish (*Rasbora heteromorpha*)
Scissor-tail (*Rasbora trilinea*)
Rosy tetra (*Hyphesobrycea rosaceus*)
Tiger barb (*Barbus tetrazona*)
Pristella (*Pristella riddlei*)

PROCEDURE: TEACHER

BEFORE LAB

Before class, distribute the following vocabulary list to students. Remember to caution students about the proper handling of live fish.

School:
A group of individuals who stay together because members show positive social responses toward each other. They move in an organized fashion.

Conspecific:
Another member of that same species.

Heterospecific:
Not a member of the same species.

PROCEDURE: STUDENTS

Go to the fish tank housing the two species of fish and observe their grouping tendencies. Do they all swim in single-species groups? Are any fish aggressive

OBTA
ILLINOIS, 1987
'Laine Gurley-Dilger
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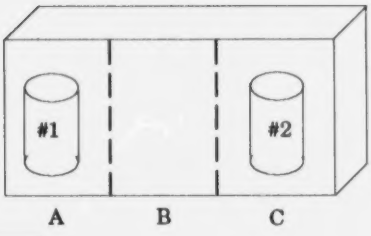


Figure 1. Test situation for Experiment 1.

to others in their group? What effect on grouping behavior (if any) results when one person taps on the aquarium frame? When a little food is sprinkled on the surface? Write down your observations.

Experiment 1.
The tendency of a lone fish to school with conspecifics

1. Draw two vertical dividing lines on the front pane of the aquarium. Label areas A, B and C.
2. Put the same number of the two species of fish in separate screw top jars, one species per jar. How many fish per jar depends on their size: 8-10 3-5 cm long fish is a good rule to follow.
3. Put one jar at each end of the aquarium.
4. Carefully put a single fish from one of the two species in the center of the aquarium. Make sure you do not direct it toward one of the jars as you release it. This is Test Fish #1. Record the following during the 10 minutes after release and enter these records in Table 1:
   - Minutes spent by the test fish in each of the three areas
   - What section fish is in at five-second intervals
   - How many times the test fish moves from one area to another
   - Any descriptions of its behavior
5. Recapture Test Fish #1 and remove it temporarily while the positions of the jars are exchanged. Replace Test Fish #1 and repeat observations and record taking as you did in step 4.
6. Recapture and remove Test Fish #1. Use one of the other species as Test Fish #2 and repeat steps 4 and 5.

Experiment 2.
Fish in a group vs. isolated fish

1. In one jar place two fish and in the other, six fish, all of the same species. Put the jars at opposite ends of the aquarium.
2. Gently put a conspecific fish in area B. During the next 10 minutes record the following information in Table 2:
   - Minutes Test Fish #3 spends in areas A, B and C
   - Number of times Test Fish #3 moves from one area to another
   - Any descriptions of its behavior and the jarred fishes' behaviors toward each other
3. Recapture Test Fish #3, exchange jar positions, replace with Test Fish #4 and repeat recordings as in step 2. Remove Test Fish #4.
4. Put an equal number of fish in each jar. Use a different individual for Test Fish #5; repeat steps 2 and 3.

   Remove all fish from jars; return to their home tanks. Wipe the divider/area lines on the tank pane. Leave the aquarium table dry and clean.

Results & Discussion

1. From your Experiment 1 tables construct a bar graph to show the mean differences between minutes spent with conspecifics vs. with heterospecifics vs. alone. Do this for both

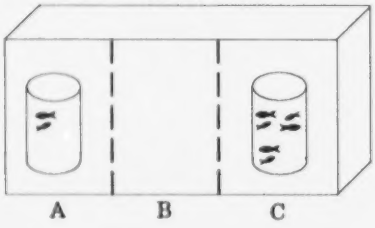


Figure 2. Test situation for Experiment 2.

species. Construct a second graph to show which species moves to new areas more often.

2. From your Experiment 2 tables, do the same as in #1 to show whether groups of more or less fish are more attractive to a lone fish.

QUESTIONS

1. How did the fish in the jars react to the Test Fish?
2. Did the Test Fish school more with its own species or with another?
3. Did the Test Fish school more with larger or smaller groups?
4. In what ways did the Test Fish interact with the jarred fish besides being near them?
5. What things did you have to understand before you could do this investigation?
6. What questions do you now have from the information you have learned?
7. What are the adaptive factors that make moving in a group advantageous to the individual?
8. Can you think of any parallel human interaction?

HELPFUL HINTS

The following are good references:

Breder, C.M. Jr. (1959). Studies on social groupings in fishes. *Bulletin of the American Museum of Natural History, 117*, 397-481.

Keenleyside, M.H.A. (1955). Some aspects of the schooling behavior of fish. *Behaviour, 8*, 183-248.

Shaw, E. (1962). The schooling of fishes. *Scientific American, 206* (6), 128-138.

Steven, D.M. (1959). Studies on the shoaling behavior of fish I. Responses of two species to changes of illumination to olfactory stimuli. *Journal of Experimental Biology, 36*, 261-280.

Williams, G.C. (1964). Measurement of consociation among fishes. *Biology Series* (Museum of Michigan State University), *2*, 349-384.

Wilson, E.O. (1975). *Sociobiology, the new synthesis* (Chapter 21). Cambridge, MA: Belknap/Harvard University Press.

STUDENT QUESTIONS: ANSWERS

1. The fish in the jars may have been oblivious to the external fish or they may have kept the external fish within their view as often as the external fish moved around the jar. Student answers will vary.
2. The Test Fish will tend to school with its own species. Unless your second species is very similar looking in color cues and size, your students will observe a greater amount of time spent with conspecifics.
3. The Test Fish will school more with larger groups.
4. The Test Fish might have tried to get into the jar, might have fled from the attentions of a jarred fish, might have tried to swim in the direction of the jarred fish.
5. Social behavior, adaptations, displays, patterns, species specific characteristics.
6. What other organisms gain benefits from being in groups? What are these benefits? What are the costs? Why don't all animals live in groups all the time?
7. Moving in a group can reduce the individual's risk of encountering a hungry predator. Being in a group makes it difficult for a certain predator to find any prey at all. Some members of a group may spot predators and alert the other members. Some may spot food which others may not see. Schools may make mate finding easier.
8. The grouping of nomadic people is one parallel.

This lab is adapted from Keenleyside, M.H.A. (1955). Some aspects of the schooling behavior of fish. *Behaviour, 8*, 183-248.

Table 1.

MINUTES SPENT IN AREA WITH: CONSPECIFICS	NO FISH	HETEROSPECIFICS	# MOVES TO NEW AREA
Test 1			
Test 2			
Means:			
Test 3			
Test 4			
Means:			

DESCRIPTION OF BEHAVIORS:

Test 1

Test 2

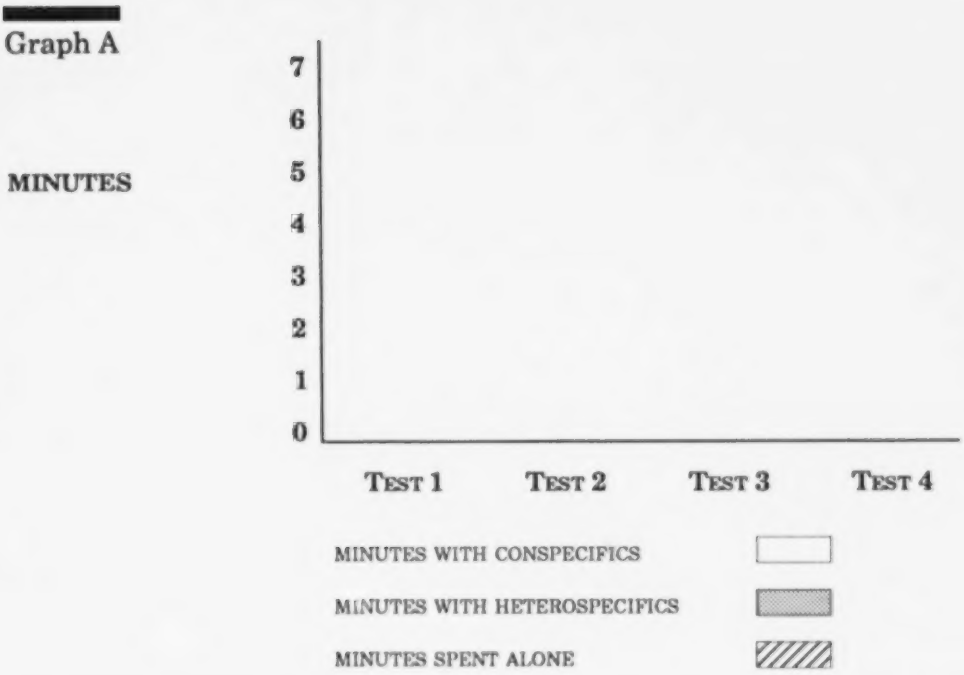
Test 3

Test 4

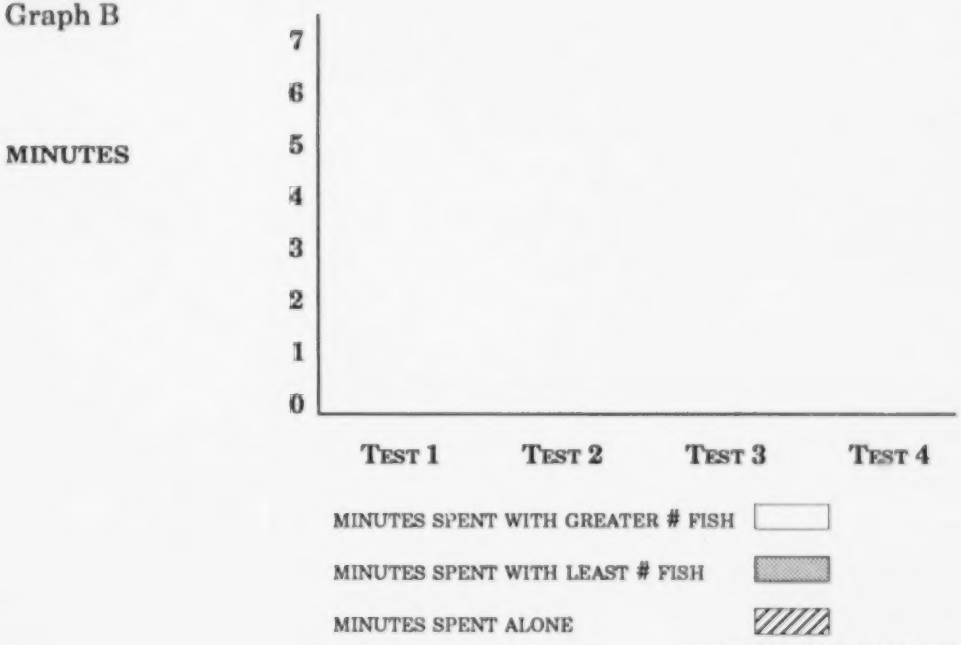
Table 2.

Minutes spent in area with: 2 Fish	6 Fish	# Moves to New Area	Description of Behaviors
Test 1			
Test 2			
Means:			
6 Fish	6 Fish		
Test 3			
Test 4			
Means:			

Graph A



Graph B



CHAPTER 4. ANATOMY & PHYSIOLOGY

The Role of Sweat Glands in Thermoregulation in the Human Body

INTRODUCTION

Humans have sweat glands all over their bodies, except for the lips and external genitalia; there are an estimated 3 million in the skin alone. Our palms contain approximately 3000 glands per square inch (Ham, A., *Histology*. J.B. Lippincott Co.).

The hypothalamus controls regulation of the body's temperature, but it is the skin nerve endings sensitive to temperature that serve as the sensory organs for the brain. The retina is the receptor for light and the hypothalamus serves as an "eye" for temperature (Benzinger).

OBJECTIVES

1. The students will demonstrate the presence and distribution of sweat glands in the skin.
2. Students determine the change in the activity of the sweat glands when there is a change in the environmental temperature and the body temperature.

MATERIALS

heat lamp
95% alcohol
1% iodine
cotton swabs
2-inch squares of Corrasable bond paper
millimeter ruler

PROCEDURE: TEACHER

BEFORE LAB

1. Get copies of Benzinger, T.H. (1961, January). The human thermostat. *Scientific American, 204*(1), 134-147. When making the request, ask for offprint #129.

DAY OF LAB

1. The iodine solution is a 1 percent aqueous solution or a 1 percent tincture solution (iodine in alcohol), both of which are safe to use on the skin. According to the U.S. Pharmocopeia, these solutions are non-irritating and are used as fungicides or germicides. As with all such germicides, however, students should be cautioned not to get them in their eyes. If such an accident occurs, the eye should be flushed with water and a physician should be consulted. Remind students that iodine stains.
2. Explain to students that the alcohol solution will be used to clean excessive skin oils off the skin where they will be mapping their sweat glands. A 70 percent alcohol solution is an acceptable substitute if 95 percent is not available.

PROCEDURE: STUDENTS

1. Divide into teams. Choose one team member to be the subject of the experiment.

OBTA
Iowa, 1988
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Lab I
The Effect of Heat on Sweat Gland Activity

1. Select two areas on your subject's skin, one where sweating occurs readily (the forehead at the edge of the hairline is a good place) and one where sweating does not occur readily (perhaps the inner side of the forearm). Clean an area approximately 3 inches square with 95 percent alcohol.
2. Paint these areas (about 2-inch by 2-inch squares) with 1 percent iodine solution and allow them to dry completely. Then lightly hold a two-inch square of bond paper on each area for 30 seconds or less.
3. Remove the paper and study it closely for bluish dots. These dots designate the location of active sweat glands. To measure the amount of sweat gland activity, mark off on each piece of bond paper a 1-centimeter square where the dots are most concentrated. The number of dots in this 1-centimeter square will be the number of record in your table.
4. Record in Table 1 the color of your subject's skin at the two testing sites.
5. Arrange the heat source so that it will fall upon the back of your subject's head and shoulders. Cover his or her neck and head with a towel or cloth so the heat from the lamp will not be directed on bare skin.
6. Turn on the heat lamp. Your subject should indicate the moment he/she feels the heat from the lamp. Continue for 10 minutes, until there is a decided change in sweat gland activity. Take a second set of readings (while waiting, read the article *The Human Thermostat*).

Table 1. The effect of heat on sweat gland activity.

SUBJECT: _____		BEFORE HEAT APPLICATION	AFTER HEAT APPLICATION
Skin color	Forehead		
	Forearm		
Sweat gland activity #dots/cm²	Forehead		
	Forearm		

Table 2. The effect of exercise on sweat gland activity.

SUBJECT: _____		BEFORE EXERCISE	AFTER EXERCISE
Skin color	Forehead		
	Forearm		
Sweat gland activity #dots/cm²	Forehead		
	Forearm		

Lab II (optional)
The Effect of Exercise on Sweat Gland Activity

If you have time, repeat Lab A, but have the subject exercise vigorously for 10 minutes. The students could run in place, run up and down stairs or do rapid sit-ups for one minute. Record results in Table 2.

Questions

1. As heat was applied, what changes did you observe in sweat gland activity and skin coloring? As the subject exercised?
2. What is the function of sweating? Of blanching or flushing of the skin? How do these adaptations relate to maintenance of internal stability?
3. Although your techniques were crude compared to those in the article, could you have predicted from your experiment the results these scientists obtained from their experiments?

Helpful Hints

Corrasable bond paper works best for this lab evidently because of its abrasiveness and starch content.

CHAPTER 4. ANATOMY & PHYSIOLOGY

Lactose Digestion

INTRODUCTION

Lactaid, yeast-derived lactose, is a commercially available product for people who are milk intolerant. People who are milk intolerant cannot digest lactose, which is milk sugar. It is a disaccharide made of glucose and galactose. In milk intolerant people, the cells of the small intestine do not produce lactase, the enzyme that breaks down lactose. Instead, the lactose is fermented by bacteria in the intestine, causing gas, bloating and diarrhea. The active ingredient in Lactaid is lactase; when this is placed in milk, digestion of the lactose occurs in the refrigerator.

Lactaid is produced by Lactaid Inc. (P.O. Box 111, Pleasantville, NJ 08232). An information sheet is sent with each order, and there is a toll-free number (800-257-8650) you can call for a free pamphlet on lactose intolerance.

OBJECTIVES

1. Students will research/review the chemistry of lactose. They should discover that lactose is a disaccharide made up of glucose and galactose.
2. Students will research/review the chemistry of enzymes. They should discover that lactase is an enzyme that breaks down lactose into glucose and galactose.
3. Students will design an experiment to test whether Lactaid does what it's supposed to do.
4. Students will collect data and control variables in their research design.
5. Students will draw and support conclusions.

MATERIALS

Lactaid
reference books
glucose test paper
glucose
milk
medicine droppers or micro test cells
concave slides
toothpicks (to mix liquids)

PROCEDURE: TEACHER

BEFORE LAB

1. Buy a four-quart supply of Lactaid liquid from a local pharmacy. Have students use micro test cell wells so only small amounts are used and it will last for several years. (For example, if student procedures call for the testing of a treated quart of milk with the Benedict's test, change it to a drop of milk, a drop of Lactaid and a glucose test strip.) Do not use the tablet form of Lactaid; it tests positive for glucose.
2. Read the information sheet that comes with the Lactaid.

DAY OF LAB

1. Discuss what Lactaid is and what it does. You may want to read selected parts of the information sheet to students. Do not read the section

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"How Lactaid Works." Students should find this out for themselves.

2. Ask students to design a controlled experiment that provides evidence that the product does what it claims. Tell them you don't believe these claims and ask them to provide you with evidence that it does. Or, set up a role playing situation; students can assume roles in a U.S. Food and Drug Administration research lab that is testing the product.
3. Gather biochemistry reference books that students can use in the lab to supplement textbooks.

Procedure: Students

1. After reviewing background information, break into small groups to design a controlled experiment that shows Lactaid does what it claims.
2. Each group will design and write a procedure for its experiment. This procedure becomes the basis for discussion with your teacher and further questioning, if needed. Actual testing will not take place until the procedure is approved.
3. After an acceptable procedure is discussed, change the measures to accommodate the use of micro test cells or depression slides.
4. Write up the experiment using this format:

Introduction and Background
Materials
Procedure
Data Table
Conclusion

Helpful Hints

Students should be able to research the definition of milk intolerance, lactose and lactase; the products of hydrolysis; and the way lactase works. If glucose testing has been done in other laboratory exercises, the next step is usually easier for them. They propose testing two cartons of milk, one with Lactaid and one without. This is a start, but they need to be asked to look for other controls. The one that they usually miss is testing the Lactaid for the presence of glucose. They should also test the validity of the glucose test with a solution of glucose. Some suggest using human subjects and testing for blood sugar levels and so on. They may have good ideas, but should be encouraged to think of other ways.

The activity works well after an introduction to the chemistry of life. Given time (two to three hours) students will use science processes and critical thinking skills, thus moving well beyond the typical fill-in-the-blank activity sheet.

Based on an activity in Oram, R.F. et al. (1986). *Biology: Living Systems, Teacher Resource Book*. Columbus, OH: Charles E. Merrill Publishing Co.

Possible Data Table

Test for Glucose	Result	Glucose Present?
milk		
Lactaid		
Lactaid & milk		
glucose		

CHAPTER 4. ANATOMY & PHYSIOLOGY

'Hypno' Disk

INTRODUCTION

This optical illusion-producing device is one of the most inexpensive, easy to build and powerful attention grabbers in my high school laboratory. The name "Hypno" Disk is designed to get students' attention; the procedure does not involve hypnosis.

OBJECTIVES

1. To build a moving optical illusion.
2. To use the "Hypno" Disk to grab students' attention.
3. To invite experimentation by students.
4. To entertain.
5. To invite the creation of other moving optical illusion devices.

MATERIALS

1 cardboard disk (at least 45 cm [18 in.] in diameter)
white posterboard (same size as disk)
pencil
eraser
black felt marker (5 mm breadth [¼ in.])
spin axle support for disk (pen, long nail or any suitable arrangement that would allow the disk to spin)

PROCEDURE: TEACHER

BEFORE LAB

1. Draw a spiral on the white posterboard with the pencil. Adjust the rough draft of the spiral so there are at least four laps before the line terminates at the center of the disk.
2. Thicken the line using the black felt marker.
3. Glue the poster paper onto the cardboard disk and punch a hole in the center (endpoint) of the spiral.
4. Place an axle (pen, nail, etc.) through the hole, and the device is ready to use. You can also mount the disk on plywood with a hand crank for spinning or power it with a motorized screwdriver.

DAY OF LAB

1. Have students sit so they can see the disk easily.
2. Hold the axle in one hand and spin the disk with the other; there is no need to spin it fast. Let the disk spin for about one minute while the students watch.
3. After the minute has elapsed, have students gaze at a fixed object in the room – a wall map, a poster, a blackboard drawing, even yourself.
4. Depending on the direction of the disk's spin, the object will appear to either expand or shrink.

PROCEDURE: STUDENTS

1. Experiment with spin direction and rates for achieving maximal effect.
2. Explain what causes the optical illusion.

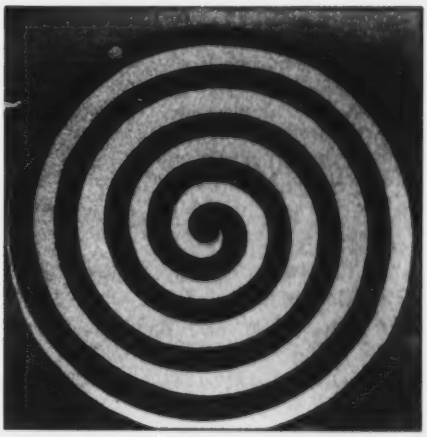
OBTA
MASSACHUSETTS, 1982
Donald W. Pottle
Shrewsbury High School
45 Oak Street
Shrewsbury, MA 01545

3. Construct disks of different colors or design and test their illusion-producing effects.

Helpful Hints

The spinning disk can be videotaped and replayed on a television monitor so that the original device need not be ruggedly made nor stored.

'Hypno' Disk is one offering of The Project Hotline, a non-profit, teacher-collaborative science project information and distance-learning outreach program. For more information, contact Donald W. Pottle, 9 Norton Way, Shrewsbury, MA 01545; 508/755-6948.



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CHAPTER 5. CYTOLOGY

Hemolysis of Red Blood Cells: A Study of Cell Permeability

INTRODUCTION

Although it is impossible to make direct observations of cell membrane structure with the materials available at the secondary level, students can perform experiments that allow them to make valid inferences about certain key features of membrane structure. This activity permits students to hypothesize the relationship existing between solute molecular size and cell permeability and to re-evaluate their predictions on the basis of lab observations.

OBJECTIVES

1. To determine the isotonic concentration for red blood cells of a sodium chloride solution.
2. To generate a hypothesis concerning the relationship between solute molecular size and cell penetrability.
3. To test these hypotheses by placing red blood cells in isotonic concentrations of solutions of varying molecular weights.
4. To suggest modifications in the original hypothesis which would account for the experimental findings.
5. To apply the concepts thus derived to situations involving the transport of materials through the cell membrane.

MATERIALS

See box

PROCEDURE: TEACHER

BEFORE LAB

Your school district might recommend that you use sheep or frog erythrocytes obtained from a distributor who can guarantee the blood to be disease-free. (Note: The AIDS virus is not transmitted from animal blood to humans.) If human blood is used, ask for a pint of "expired" blood from your local Red Cross chapter. (Less than 1 in 50,000 samples may contain the AIDS virus even after screening, according to the American Red Cross.)

DAY OF LAB

Give each student a copy of the introduction to the lab (p. 52).

PROCEDURE: STUDENTS

After you've read the introductory paragraph and answered the questions, you're ready to begin.

Part I. Determining the Isotonic Concentration of NaCl

1. Fill seven test tubes half full with the following solutions of NaCl:

   $\frac{1}{9}$M
   $\frac{1}{10}$M
   $\frac{1}{11}$M
   $\frac{1}{12}$M
   $\frac{1}{13}$M
   $\frac{1}{14}$M
   $\frac{1}{15}$M

2. Fill one tube half full with distilled water.
3. To each vial, add three drops of heparinized blood. Mix each tube gently but thoroughly by tapping the test

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MONTANA, 1988
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Materials List

I. Solutions

1. NaCl stock solution – 29.2 g in 500 ml H_2O.

2. Dilutions:

Concentration				ml Stock	ml H_2O
.11	M =	$\frac{1}{9}$	M	62.5	437.5
.10	M =	$\frac{1}{10}$	M	55	445
.09	M =	$\frac{1}{11}$	M	50	450
.08	M =	$\frac{1}{12}$	M	45	455
.076	M =	$\frac{1}{13}$	M	42	458
.071	M =	$\frac{1}{14}$	M	38	462
.066	M =	$\frac{1}{15}$	M	35	465

3. Isotonic solutions of each:

Substance	Amount of Substance in 500 ml H_2O
Lithium chloride	3.08 g.
Sodium chloride	4.25 g.
Potassium chloride	5.4 g.
Methyl alcohol	4.4 ml.
Ethyl alcohol	6.5 ml.
Propyl alcohol	7.8 ml.
Thiourea	10.6 g.
Glycerol (glycerin)	12.2 ml.
Glucose (dextrose)	25.2 g.
Sucrose	48 g.

II. Equipment – per two students

10 10 test tubes in a test tube rack
1 eyedropper
1 erythrocytes/blood
1 500 ml distilled water

Hemolysis of Red Blood Cells: An Introduction

In this activity you will be working with hypotonic solutions. Red blood cells placed in these solutions will take up water, and because they do not have a rigid cell wall to exert a back pressure on the cell membrane, they will burst, releasing hemoglobin and other protoplasmic contents into the surrounding medium. The bursting of a red blood cell due to the intake of water in hypotonic solution is called hemolysis. As hemolysis occurs, the medium which appeared cloudy because of the presence of millions of intact and refractile red cells, clears and becomes a transparent, cherry red solution. Only the "ghosts" (cell membranes) of the cells remain and do not refract light sufficiently to cause turbidity in the medium.

Answer the following questions based on what you've just read:

1. What is a hypotonic solution?
2. Why do red blood cells burst in a hypotonic solution?
3. How can we tell when the hemolysis of red blood cells has occurred?

Table 1

Chemical	Molecular Weight	Predicted Hemolysis	Actual Hemolysis
Lithium chloride	43		
Sodium chloride	58.4		
Potassium chloride	74.5		
Methyl alcohol	32		
Ethyl alcohol	46		
Propyl alcohol	56		
Thiourea	76		
Glycerol	92		
Glucose	180		
Sucrose	342		

Lab Observations

Chemical	Time Blood Added	Time at Which Hemolysis Observed	Time Required for Hemolysis
Lithium chloride			
Sodium chloride			
Potassium chloride			
Methyl alcohol			
Ethyl alcohol			
Propyl alcohol			
Thiourea			
Glycerol			
Glucose			
Sucrose			

tube with your finger; allow them to stand for 10 minutes. Note the amount of hemolysis (bursting of cells) that takes place as indicated by the color of the supernatant fluid and the quantity of settling, intact cells. Note the greatest concentration of NaCl in which hemolysis occurred. The next highest concentration would be the isotonic solution for red blood cells (r.b.c.). These concentrations delimit the fragility point for the cells. This test provides one clinical means of diagnosing certain of the anemias found in humans. Fragility increased in hemolytic anemia and decreased in pernicious anemia in man.

4. Answer the following questions:
   a) What was the greatest concentration of NaCl in which hemolysis occurred?
   b) What concentration of NaCl was the isotonic solution for red blood cells? Explain your choice.

Part II: Penetrability of Molecules Through the Membrane

1. In this experiment you will use isotonic concentrations of a variety of different chemicals. Some of these will cause hemolysis of r.b.c. Why?
2. To give you one means of estimating the size of the molecules used, the molecular weights are provided in Table 1. Predict the chemicals you feel will cause hemolysis in isotonic concentrations by placing a check in the prediction column.
3. Explain your predictions.
4. Rinse out the test tubes used in the first exercise and fill half-full with the above solutions. To each vial add three drops of blood and stir gently. Note the time at which you add the blood to each tube. Record the time at which hemolysis occurs in each tube in which a reaction is apparent. (Solution becomes cherry red above the settling cells). Discontinue observations after 20 minutes.
5. Place a check in the "Actual Hemolysis" concentrations.

Helpful Hints

In making their original prediction, students will invariably suggest that all the molecules having a lower molecular weight will penetrate the membrane. They are surprised when LiCl, NaCl and KCl do not provide the expected results.

Summing Up

Have students review background information in the introduction and study their data before answering:

1. In general, what do you conclude about molecular size (as indicated by molecular weight) and permeability?
2. Lithium chloride, sodium chloride and potassium chloride are electrolytes. The other substances are non-electrolytes. Explain any differences noted between the electrolytes and the non-electrolytes in the average time required to cause hemolysis.
3. Predict the outcome if plant cells were subjected to experiment conditions.
4. Suppose r.b.c. were placed in pure water. Predict what would happen and explain your answer.
5. Revise your model of cell membrane structure to satisfactorily explain the experimental observations.
6. Numerous fresh water protists (one-celled organisms) live and thrive in water containing very few dissolved minerals. What water balance problem do these cells continually face? How might they solve this?
7. Freshwater fish face a similar problem to that of the protist above: Their gill filaments, which contain thin membranes, are constantly exposed to water, allowing the rapid diffusion of oxygen. How might these organisms solve this problem?
8. Explain the water balance problems faced by a fish migrating from freshwater to saltwater. Suggest mechanisms to solve these problems.

CHAPTER 5. CYTOLOGY

Turn Your Classroom into a Giant Cell

INTRODUCTION

Imagine for a moment that you have enlarged the nucleus of an atom to the size of a pin head; how far away would the electron in the first orbital be? The answer is 10 meters. To put this into perspective, imagine that you enlarge the pin head to the size of a baseball; the first electron would be the distance of the last seat in a baseball stadium.

One of the most difficult problems students have in studying cell structure and function is the size of the organelles within a cell. If you compare a cell to the size of your classroom, how big would all the organelles within it be? What objects in the classroom could you use to illustrate this? The math and metric conversions from the very small to the very large may make this seem difficult to do. But if you simplify the mechanics involved, it does not appear difficult after all.

OBJECTIVES

1. To bring the size of a cell and the organelles in it to a scale within the classroom.

MATERIALS

use your imagination!

PROCEDURE: TEACHER

DAY OF LAB

Explain the following mathematical procedures to the students:

1. To enlarge a 6-inch pencil to the length of a classroom, measure the classroom in feet and convert to inches. For example, my room is 42 feet or 504 inches and the pencil is 6 inches long.
2. Divide the length of the pencil into the length of the room and you get a factor of 84. Therefore, every part of the pencil would be enlarged by the factor of 84 to make all the letters on the pencil in proportion. The same is true of a typical cell.
3. If your classroom is 42 feet or 504 inches long, then 2.54 cm x 504 will give the room length in cm (1 in. equals 2.54 cm), which equals 1280.16 cm. If there are 10 mm in 1 cm, then 1280.16 cm = 12801.6 mm. And, if there are 1000 υm in 1 mm, then 12801.6 mm = 12801600 υm.
4. Take a typical liver cell of 20 υm. To enlarge it to the size of the classroom, divide the length of the cell into the length of the classroom to get the factor to multiply by. For example, 12801600 υm ÷ 20 υm gives you a factor of 640080. Every organelle within the cell must be multiplied by this factor to make all parts of a cell equal in proportion to the classroom cell.

$$\frac{\text{υm}}{\text{organelle}} \times 640080 = \frac{\quad}{10{,}000}\text{ υm} = \frac{\quad}{2.54}\text{ cm} = \quad\text{in}$$

Or,

$$\frac{\text{υm}}{\text{organelle}} \times 64 = \quad\text{cm} = \quad\text{in}$$

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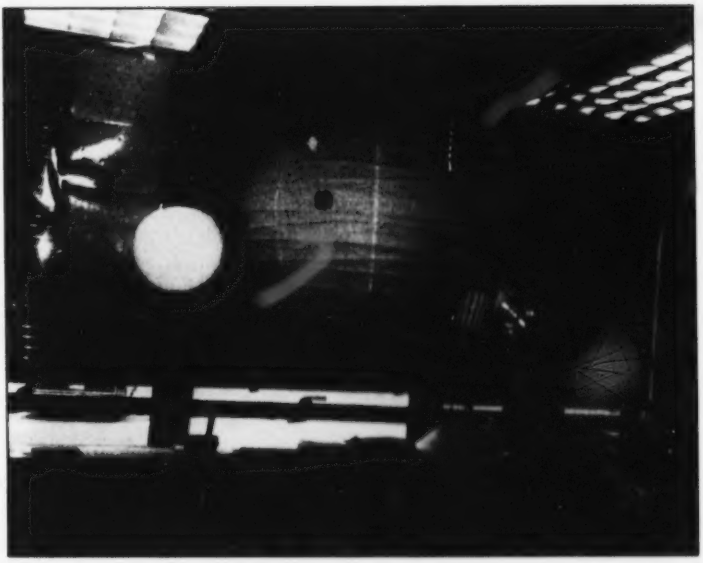
[**Note:** If the parts you measure are in nm, convert it to υm by dividing by 1000 or to A by dividing by 10000. In electron micrographs of cells, for the power 1000X, every 1 mm on the picture equals 1 υm. So, in a 1300X picture, every 13 mm equals 1 υm.]



PROCEDURE: STUDENTS

1. Once you understand the mathematics of the cell and nucleus, complete the giant cell chart's organelles.

SUMMING UP

Have students volunteer to build organelles to scale from materials at home or in shop (see photo).

STUDENT SHEET: MEASUREMENTS USED IN MICROSCOPY

1 cm = $\frac{1}{100}$ m	1 cm = 10 mm	1 cm = 10,000 υm
1 mm = $\frac{1}{10}$ cm	1 mm = 1000 υm	1 cm = 10,000,000 nm
1 υm = $\frac{1}{1000}$ mm	1 υm = 1000 nm	
1 nm = $\frac{1}{1000}$ υm	1 nm = 10 A	
1 A = $\frac{1}{10}$ nm		

1 m = 10 x 2 cm = 10 x 3 mm = 10 x 6 υm = 10 x 9 nm = 10 x 10 A

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Curtis, H. (1987). *Biology* (4th ed.). New York, NY: Worth Publishing.

DeRoberts, E.D.P., Nowinski, W.W. & Francisco, A. S. (1970). *Cell biology* (5th ed.). Philadelphia: W.B. Saunders Co.

Porter, K. & Bonneville, M. (1973). *Fine structure of cells and tissues* (4th ed.). Philadelphia: Lee and Febiger.

Carolina Biological Supply Company. *1988-89 calendar*. Burlington, NC: Author.

The Giant Cell

Cell Parts	Size in υ	Conversion	i.e.
Nucleus	5υ-7υ (6υ)	384cm/151in/12.5ft	
Nucleolus	2υ	128cm/50.4in/4.2ft	
Nuclear envelope	20-40nm/.02-.04υ	1.2-2.5cm	
pores	.125υ	8cm/3.1in	
Chromosomes	2.4nm/.0024υ D	.15cm	
Cell membrane	6nm/.006υ	.384cm/.151in	
E. R.	01-.08υ	.64-5.12cm	
Ribosomes	25nm/.025υ	1.6cm/.629in	
a.a.	.8nm/.0008υ	.05cm/.02in	
Mitochondria	1.5υ L X .5υ D	96cm/37in/3ft L X 32cm/12.5in D	
Vacuole	>100nm D/.1υ	>6.4cm/2.5in	
Vesicle	<100nm D/.1υ	>6.4cm/2.5in	
Lysosome	.25-.8υ D	16cm/6.3 in - 51cm/20.1in	
Golgi	1υ L X .5υ W	64cm/25.2in X 32cm/12.5in	
Centriole	.2υ D X .4υ L	12.8cm D X 25.6cmL	
Microtubules	20-25nm/.02-.05υ D	.192-.384cm/ .01-.07in	
*Chloroplast	5.5υ L X 2υ D	352cm/138.5in/11.5ft	
grana	.6υ D	38.4cm/15.1in	
*Cell wall	1-1.3υ	64cm/25.2in/2.1ft	
E. coli	1.5υ L X .5υ D	96cm/37.8inX32cm/12.5in	
Flagellum	10υL X .015υ D	640cm/252in/21ftX.96cm/	
Virus T4	200nm/.2υ	12.8cm/5in	
AIDS	1000A/100nm/.1υ	6.4cm/2.5in	
Hemoglobin	6.4nm/.0064υ	.40cm/.16in	
Water	.4nm/.0008υ	.0256cm/.01in	

*plant cell only

The Giant Cell

Cell Parts	Size in υ	Conversion	i.e.
Nucleus			
Nucleolus			
Nuclear envelope			
Chromosomes			
Cell membrane			
E.R.			
Ribosomes			
Mitochondria			
Vacuole			
Vesicle			
Lysosome			
Golgi			
Centriole			
Microtubules			
Microfilaments			
*Chloroplast			
*Cell Wall			
Bacteria (your choice)			
Virus (your choice)			

*plant cell only

CHAPTER 5. CYTOLOGY

Pipe Cleaner Genetics

INTRODUCTION

An understanding of the concepts of mitosis and meiosis is needed to understand genetics; both are difficult for students to understand. Some students can memorize and regurgitate the terms, but some hands-on experience greatly facilitates the understanding of the concepts. This procedure is used after class discussion of mitosis and meiosis, and when learning about single- and two-trait crosses.

OBJECTIVES

1. Students will learn that chromosomes occur in pairs.
2. Students will compare/contrast mitosis and meiosis, observe the relationship between mitosis and genetic continuity and meiosis and variety.
3. Given the occurrence of a trisomy, students will demonstrate the mechanisms of nondisjunction.

MATERIALS

colored chenille pipe cleaners
wooden beads
yarn
white postage labels, cut into small pieces to label as "genes"

PROCEDURE: TEACHER

BEFORE LAB

1. Label one chromosome (each chromatid) "A" and the other "a." Label the other "T" and the other "t." (The first two activities I use in class concern albinism and PTC tasting.) If students ask what the letters are, tell them they are genes, or the "characters" Mendel wrote about.

DAY OF LAB

1. When students are completing Mitosis step 3, show them how pipe cleaners fit through the wooden bead.
2. For Mitosis step 4, use yellow chalk to draw in centrioles and spindle fibers on the table (it wipes off easily).
3. For Meiosis step 3, use the blackboard or overhead to show the different ways chromosome pairs may line up. For example, a chromosome pair may be situated so that the chromosome carrying "gene A" is on the right and the chromosome carrying "gene a" is on the left. The opposite may also occur for the chromosomes labeled with "t" and "T," and, as the pairs separate, a gamete may then contain "A" and "T," "A" and "t," "a" and "T" or "a" and "t." This, therefore, demonstrates one source of variety.

PROCEDURE: STUDENTS

Mitosis

1. Your teacher will give you pieces of colored pipe cleaners (four pieces of equal size in one color and four of equal size in a second color), two wooden beads and a piece of yarn approximately 70-80 inches long.
2. Make a circle (the cell membrane) on your desk or table with the yarn .
   a) When is the cell going to divide?
   b) What important events occur in

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the cell during **interphase**?
   c) Are individual chromosomes visible during this stage?
3. For this lab, cell division begins with **prophase** when chromosomes become distinct and visible under a microscope. Show your cell with two pairs of replicated chromosomes at prophase.
   a) What does the wooden bead represent?
   b) What does each pipe cleaner represent?
4. Show your cell in **metaphase**.
   a) Where are chromosomes at metaphase?
   b) Does everyone have them lined up in the same order?
   c) Does that matter?
   d) Where is the spindle fiber attached?
5. Show your cell at **anaphase**.
   a) What is happening to the spindle fibers?
   b) What is happening to the chromatids?
   c) What are they now called?
6. Show your cell at **telophase**.
   a) What is happening to the cell membrane?
   b) What other events occur?
   c) How does the size of the new cells compare to the original cell?
   d) Do the new cells have the same "genes" as the original cell?
   e) Why is this important?

Meiosis

1. Follow the same procedure as for mitosis, except at **prophase I**, remember that the chromosome pairs (homologs) move close together (synapsis), forming tetrads.
2. During **metaphase I**, remember that each pair of chromosomes attaches to a separate spindle fiber, rather than each chromatid, as during mitosis.
3. a) Does everyone have their pairs in the same order (look at the "genes" or letters)?
   b) What are some of the combinations you have?
   c) Give some examples of variety in a population.
   d) Why do you think variety is important to populations?
4. During **anaphase I**, which follows, the spindle fibers contract; one pair of chromatids of each tetrad is pulled to each pole. **Telophase I** follows. Label **prophase I** as the primary spermatocyte/oocyte and **telophase I** as secondary spermatocyte/oocyte.
5. **Meiosis II** follows the same procedure as mitosis, using the two cells resulting from meiosis I. The chromatids now separate; four cells result. (This is why the yarn "cell membrane" must be fairly large.)
6. a) What "genes" are in each of your gametes?
   b) When a parent is heterozygous for two traits, what gametes might be produced?
   c) How many genes for a trait are in each gamete?
   d) Which of Mendel's laws does this illustrate?
7. Take one of your gametes and combine it with another student's.
   a) What combinations of genes did you make?
   b) What would happen if "a" were a **lethel gene**?
   c) If both parents are heterozygous for "a," what are the chances your child will: have the disorder, be a carrier, not be a carrier?
   d) If one parent is homozygous "AA," what are the chances your child will have the disorder?

Helpful Hints

I have found this helpful when illustrating human genetic disorders, single gene traits and two-trait crosses. Having the class discover all possible gametes enhances their understanding of a Punnett square and their ability to determine all possible offspring.

CHAPTER 5. CYTOLOGY

Acting Out Protein Synthesis

INTRODUCTION

Students often have trouble visualizing the process of protein synthesis. This activity provides one way of making the abstract ideas of molecular biology more concrete.

OBJECTIVES

This activity can make protein synthesis "come alive" and helps teach a complex concept in a concrete manner.

MATERIALS

2 paper grocery sacks
1 pair scissors
red and black markers
36 index cards
transparent tape (1 roll per class)
18 safety pins or paper clips

PROCEDURE: TEACHER

BEFORE LAB

1. From a grocery sack, cut out two strips of paper that are each 8 inches wide and 36 inches long. Tape the strips of paper together so as to construct a strip that is almost 72 inches long. Then tape the two ends together to form a loop that will be worn as a sash. Use a black marker to print on the sash a double stranded sequence of A's, T's, C's and G's, the bases of DNA (for an example, see Figure 1).
2. From a second grocery sack, construct a 6-foot-long strip of paper about 6 inches wide. Use a red marker to print on it a single stranded sequence of A's, U's, C's and G's that are complementary to one strand of the above DNA model. This will serve as a model of mRNA. For an example of the base pairs in this mRNA model, see Figure 2.
3. Obtain as many index cards as there are codons in your mRNA model (excluding, of course, the termination codon—UAA). For each mRNA codon, print the name of its corresponding amino acid on an index card. Affix a loop of transparent tape to the back of each amino acid card so that they can be attached to the chalkboard during class. As an example, the amino acids coded for by the above mRNA would be: METHIONINE-LYSINE-TRYPTOPHIAN-ALANINE-ASPARTIC ACID-GLUTAMINE-HISTIDINE-PROLINE-PHENYLALANINE-ISOLEUCINE-CYSTEINE-GLUTAMIC ACID-ARGININE-ASPARAGINE-GLYCINE-LEUCINE-SERINE-THREONINE-termination.
4. For each of the amino acid cards, take another index card and construct an anticodon card by printing the sequence of three RNA bases that would be complementary to the codon. For example:

   codon: AUG
   amino acid: methionine
   anticodon: UAC

   Attach a safety pin or paper clip to each of the anticodon cards. They will be worn by the students who will role play as tRNA molecules.

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Day of Lab

1. Tell students to imagine that the classroom is a typical cell. An attached office/storage room can be the nucleus.
2. Over one shoulder drape the sash and tell the students that, as the teacher, you get to play the part of the DNA molecule (a few groans are sometimes heard).
3. Select a student to play the role of a ribosome and have him or her stand near the chalkboard at the front of the class. The student will build a protein molecule by attaching amino acids end to end on the board.
4. Assign several students the roles of tRNA molecules. Give each tRNA an index card with an anticodon (for example, AGC) printed on it. Have them attach their anticodons to their shirt or blouse collar with a safety pin or paper clip. Then hand each tRNA his or her appropriate amino acid card.
5. Now the drama is ready to begin. The tRNA molecules wait eagerly to deliver their amino acids to the ribosome. The ribosome stands at the chalkboard, eager to build protein but not knowing which amino acids should be put together in what order. Stand in the doorway of the nucleus and, as a frustrated DNA molecule, lament the fact that you know how to build protein ("just look at my sequences of bases!"), but are stuck in the nucleus with no way of reaching out and telling the ribosome what you want done. Just then, someone usually pipes up, "Make mRNA!"
6. Go back to your desk in the office and pull out the six-foot strip of grocery sack. Reaching through the doorway of the nucleus into the cytoplasm, hand this long mRNA molecule to the ribosome, who then proceeds to read aloud, one at a time, the codons printed on it. Each tRNA checks the anticodon affixed to his collar and listens for the complementary codon which serves as his cue to walk up to the board and deliver the amino acid to the ribosome. The ribosome attaches the amino acid to the board, then reads off the next codon. When the end of the mRNA molecule is reached, the students will be able to see the finished product – a string of amino acids – on the chalkboard.

Procedure: Students

Protein synthesis, the "central dogma" in biology, is the process whereby DNA (genes) controls the manufacture of proteins (traits). Today we will act out the roles of the important molecules in this drama. The cast of characters includes the following:

1. **DNA**
   Although DNA is the star of the show, it is confined to the nucleus of the cell and must produce an mRNA molecule which is able to leave the nucleus, carrying DNA's instructions out into the cytoplasm.
2. **ribosome**
   This supporting actor plays a crucial role as the one who builds protein molecules by reading and following the DNA's instructions that are written in the mRNA molecule. *The ribosome will read the mRNA molecule three bases at a time (each group of three bases is called a codon). As each codon is read, a tRNA molecule will deliver an amino acid to the ribosome. As amino acids are delivered one by one, the ribosome should tape them to the chalkboard in a long string. This long string of amino acids will represent a protein.*
3. **mRNA**
   The message (written by DNA) which travels from the nucleus out into the cytoplasm. mRNA is then read by the ribosome.

Figure 1.

TAC-TTT-ACC-CGA-CTA-GTT-GTA-GGA-AAA-TAA-ACA-CTT-TCT-TTA-CCA-AAT-AGA-TGA-ATT
ATG-AAA-TGG-GCT-GAT-CAA-CAT-CCT-TTT-ATT-TGT-GAA-AGA-AAT-GGT-TTA-TCT-ACT-TAA

Figure 2.

AUG-AAA-UGG-GCU-GAU-CAA-CAU-CCU-UUU-AUU-UGU-GAA-AGA-AAU-GGU-UUA-UCU-ACU-UAA

4. **tRNA molecules**
   These molecules serve to deliver amino acid molecules to the ribosome. The ribosome then strings the amino acids together to build protein molecules. *Each tRNA molecule in this play will be given an anticodon by the teacher (which should be attached to the shirt or blouse), as well as an amino acid molecule. As the ribosome reads off the mRNA codons, each tRNA molecule should listen for the codon that is complementary to the anticodon that he/she is wearing. When a tRNA player hears the codon that is complementary to his/her anticodon, he/she should walk up and deliver the amino acid to the ribosome.*

Helpful Hints

Before the drama of protein synthesis is played out in your classroom, you may want to have students take a look at a genetic code chart (shown in most biology textbooks). It would be helpful if the students kept this code chart in front of them throughout the drama.

Summing Up

Some possible questions that could be discussed in class following the drama:

1. Describe the role of DNA in the cell. Describe the individual roles of mRNA, rRNA (ribosomes) and tRNA.
2. What is transcription?
3. What is translation?
4. In what ways was this drama like the real world within a living cell?
5. In what ways was this drama not like the real world within a living cell?
6. From the beginning of the drama to the end, point out where in the process mistakes (mutations) could have happened.

Characteristics of Life

INTRODUCTION

We often have trouble distinguishing between living and nonliving materials. This exercise will allow students to see the difficulty in defining and recognizing living materials.

OBJECTIVES

Students begin the lab by writing down two characteristics they believe will define any living thing. They end it by developing a list of general characteristics of living things.

MATERIALS

Petri plates
Duco cement (cement used must contain toluol)
water
overhead projector

PROCEDURE

1. Ask each student to write down any two features of living organisms that they believe will define life (5-10 minutes).
2. Choose various students to share one or two of their characteristics; have others think of exceptions or modifications (10-20 minutes).
3. Conclude discussion by listing on the board the characteristics of most living organisms (5 minutes).
4. Without the students seeing preparations, take a Petri plate one-third full of water and add a small drop of Duco cement. In sight of the students, place the dish on the overhead projector. The drop will "swim" around as the cement chemically reacts with the water. Ask students to evaluate whether the experimental material is alive. (Usually some will think it's a trick, but most believe the material is alive.) Drop two small bits of Duco cement in another dish (out of students' view) and place on the overhead. Drops will appear to be "swimming" together. The other drop may be slowing down and students usually comment that it is "dying." Ask how they know the material is alive. After discussion, put a Petri plate of water on overhead in students' view and drop one drop of Duco cement into plate (10-15 minutes).
5. Summarize with a discussion of the difficulty of defining life here on Earth as well as in other solar systems. (The book *Andromeda Strain* has a good discussion of this topic.)

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CHAPTER 1. QUICK ALTERNATIVES

Using Rotating Lab Systems

INTRODUCTION

The laboratory is one of the most important aspects of science education, yet the experience students receive often is limited or less than satisfactory. One reason may be the difficulties involved in trying to operate a quality lab program. Teachers may have to cope with students of diverse ability, shortages of basic classroom equipment and an inability to address students' special needs and interests.

Introducing a rotating lab system into an existing program is one way to increase effectiveness and solve problems. The system involves setting up a series of different labs and rotating the students through them. On lab day, each student or team of students works on a different lab; the following lab period they move on to the next lab in the series.

OBJECTIVES

1. To give students an exciting and challenging laboratory experience that might otherwise be unavailable.
2. To have students maximize use of limited equipment, contribute their ideas and work at their own pace.

MATERIALS

The most difficult part of starting a rotating lab system is selecting and organizing the labs. Not all labs work well in this type of system: for example, those requiring numerous fresh preparations or hard-to-maintain cultures.

Safety rules, state requirements, scientific method and enjoyment are important considerations. Excellent labs are available on almost any topic, but most will have to be modified to meet the teacher's specific needs. A good program should include topics that are of special interest to students with as many concepts as possible.

Once you select labs, you'll need supplementary information and reference material. Make data sheets and three sets of questions for each lab. Use questions that ensure students make observations, interpret data and practice research and critical thinking.

After gathering lab materials, assemble them into kits. Get students involved; this will also make the work go more quickly. Store kits in boxes, dish pans or other containers for easy movement from storage areas to lab stations. When lab and lecture areas are separate, store kits at the lab station.

Data sheets and questions can be compiled into lab books or given as handouts before each lab. Incorporate a reference table into the lab area. Make available general reference materials and references specific to the labs.

Expect some confusion the first time students use the rotating lab system. You'll find they adapt quickly.

PROCEDURE

Procedures vary depending on the circumstances. These guidelines will prevent most potential problems.

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1. Assign lab kits numbers that correspond with those on lab stations containing required fixtures. Having a limited number of sinks, computers or gas jets should not be a problem. Many labs will not require them, and those that do can be matched to the appropriate stations.
2. The labs that take the longest to do should not be consecutively numbered. When possible, group labs dealing with related concepts.
3. Make available optional labs that can be done for extra credit or in place of certain other labs. Use optional labs to challenge your best students or address special interests.
4. Assign each student a starting number; from there they can move through the labs consecutively. On the day of the lab, inform students which of the three sets of lab questions they should complete. A lab that is completed more quickly than the others can include more problems or research questions.
5. Have available plenty of different labs; it's best to have six or more optional labs in a set. This system seems to work better when partners are not used. If you do use lab partners, have one kit per student.
6. Have students alert you when consumable materials are low. Recruit students to help mix solutions, maintain materials and do other jobs.
7. Grading labs on a percentage basis makes it possible for all labs to have the same point value. Not all of a set will be completed in the same grading period.
8. A rotating lab system should supplement an existing program. Start the year with more traditional labs so students become familiar with lab equipment and procedures. Phase in the rotating system later in the year.

Summing Up

A rotating lab system is not for every school or teacher. It requires a great deal of time and energy to organize and the topics covered in class usually don't coincide with the lab on which a student is working. Teachers in well equipped facilities or with low student–teacher ratios may see little benefit from this program.

The teachers who will benefit from rotating labs have:

- large classes
- low budgets
- two or more sciences–for example, biology and earth science
- tracked classes (Labs can be adapted to high or low abilities.)
- poor lab facilities

Biology is one of the hardest classes to adapt to a rotating system, but more than half the labs most teachers cover can easily be incorporated. Biology or ecology classes that include considerable field experience offer some of the best situations for rotating labs. Consider various aspects of water analysis, physical environmental factors, aquatic botany and aquatic zoology.

Some advantages of this system:

1. The total equipment cost is lower than that of a complete traditional program.
2. Much less class time is needed for set up and take down.
3. Each lab requires only one or two sets of equipment, making it possible for students to experience labs that otherwise would be too costly.
4. It's easy to include or change optional labs to challenge gifted students, meet special needs or fulfill individual interests.
5. Shortages of major equipment such as sinks, gas jets, computers and electrical outlets are less of a problem. Many labs will not require them; those that do can easily be matched with available facilities.
6. More individualized attention leads to improved communication between students and teachers.

Chicken Dissection & Barbecue

INTRODUCTION

Col. Sanders unintentionally advanced the cause of biology by helping to spread the good news about fried chicken. Teach students about avian anatomy while they have fun barbecuing the subject of the study.

OBJECTIVES

1. Students will demonstrate the osteology and musculature of the chicken and have a good time as well as a good meal.
2. A low level learning experience (knowledge) will be applied to higher levels (synthesis and application).

MATERIALS

1 large uncut fryer per class
4-6 scalpels
4-6 Bunsen burners
1 probe (wooden handle) per student
Petri dishes
1 boning or paring knife
catsup
barbecue sauce
salt & pepper
chicken skeleton diagram (Figure 1)

PROCEDURE

1. Place salt, pepper, barbecue sauce and catsup in Petri dishes. Have the chicken, a platter of some kind, boning knife, probes and scalpels at the front.
2. Put the diagram (Figure 1) on the overhead along with unlabeled diagrams.
3. Have students cut up the chicken under your supervision. The students use the boning knife to exise some part, such as a leg or breast. They then label the appropriate part of the diagram. Have students volunteer for this; a half dozen students usually is sufficient. To save time, shred the rest of the meat from the bones yourself. Place all the meat on a platter.
4. Students really enjoy the next part–eating the lab. Turn on the Bunsen burners and have students select a piece of chicken with sterile scalpels and place it on a probe. Be sure these have wooden handles; the flame will sterilize them. Make sure students wash their hands thoroughly after handling raw chicken.
5. Include with this lesson a discussion of *Salmonella*, a nasty genus containing pathogens causing illnesses ranging from typhoid to food poisoning. Chickens harbor a virulent strain that wreaks havoc in the human gut. Stress to students the importance of proper cooking and washing of hands and any utensils or surfaces that come in contact with raw chicken. Proper cooking neutralizes the bug; not washing after handling uncooked fowl often makes folks wish they had.

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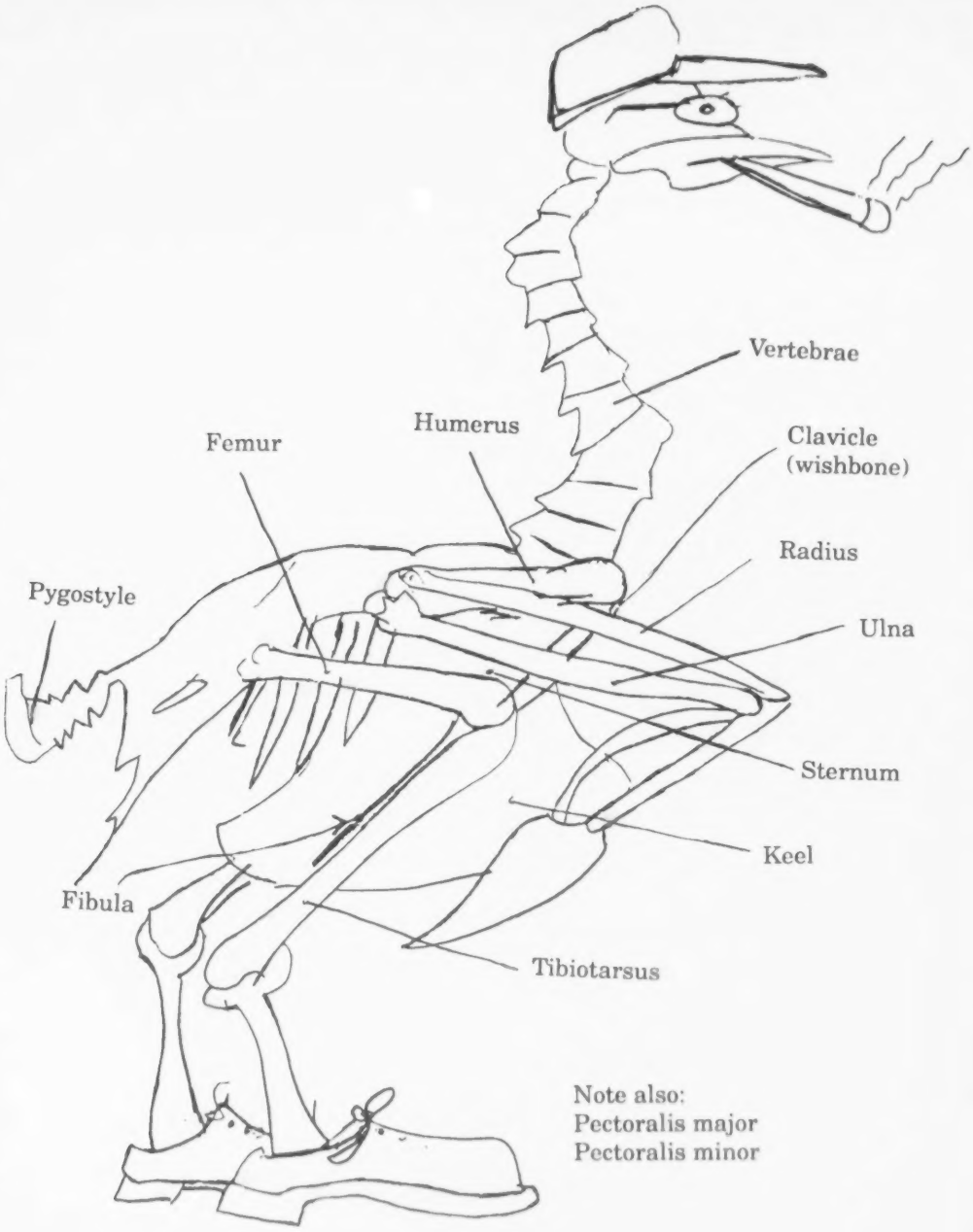

Figure 1. Chicken skeleton diagram.

CHAPTER 1. QUICK ALTERNATIVES

Reaching Future Caretakers & Decision Makers

INTRODUCTION

Our nation is at risk of producing citizens who cannot function in a scientific and technological world. Many students enter the adult world unaware or insensitive to the things going on around them. Too often they make uninformed decisions as voters and uninformed decisions about their personal well being and that of other organisms. Very often they are unable to research a problem and arrive at a viable solution.

OBJECTIVES

1. Focusing not just on the students who are interested in science, but those who will go on to other careers as well.
2. Helping students see the relevance of science to the real world, through the world they see on TV, in newspapers, magazines and in their own hometown and backyard.

MATERIALS

Vary, depending on the lab

PROCEDURE

Too much straight lecturing loses students. I usually make my lectures 20 minutes, to match their attention span; if the lecture needs to be longer I make 35mm slides to enhance interest. The following ideas can be used or adapted to spark interest in students.

1. Repeating the classic teaching techniques too often (lecture, labs, questions, films) can be boring for teacher and students alike. Instead, build a class activity around a current event. Take an article–for example, one on solid waste and the problems associated with it–and divide the class into groups to design campaigns for recycling. These campaigns can take the form of a skit, display, commercial or something else. Turning what students might perceive as a boring topic into something fun will increase retention and improve student attitudes.
2. Ask questions about an article, but instead of having students write their answers, have them draw them. Or, have them create a concept map.
3. Show a filmstrip without sound. Then have students research and write the script.
4. When studying heredity, do a "Design a Kid" activity. Students use coins to determine "their child's" gene type and then draw him or her. Or, they can design a child to survive in a future environment (if environmental problems continue, such as higher temperatures or less water).
5. Have students create a cell commercial to "sell" a cell part.
6. When studying biomes and the problems associated with them, have students design their yards to help wildlife, write to legislators, design and write a newsletter and teach younger students about whales.

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WASHINGTON, 1985
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7. Have students read an article on genetic engineering and make judgments about what is possible, probable, desirable. Students decide on the pros and cons of the technology.
8. Teach students how to apply data to real life situations. Have them perform a nutrient lab with plants and then apply those data to real life–for example, by explaining why their lawns are not green.
9. Make students into activists. In addition to writing legislators, have students clean up areas around school, add birdhouses and plants, change part of their lifestyle (recycling is a good activity to encourage) or adopt an animal or an acre of land.

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CHAPTER 2. STUDENT PROJECTS

Promoting Biological Relevance Via the Monera Kingdom

INTRODUCTION

Researching and reporting on some of the pathogenic bacteria are relevant for high school students since most are aware of the role bacteria play as agents of disease. The cause, acquisition, symptoms, cure and/or treatment and special characteristics of the more common diseases are included in both a written and oral report. Additional relevance can be emphasized through the completion of a personal health form that will serve as a reference on future applications and official forms. And finally, a classroom debate or discussion on the DTP vaccine and the ethics of that vaccine could be included.

OBJECTIVES

1. Students will investigate a disease caused by a Moneran.
2. Students will present a written and oral report on a pathogenic Moneran.
3. Students will develop, compose and create a mini-reference guide as a result of outlining oral reports.
4. Students will research and list those diseases and/or vaccinations that they have had.
5. Students will investigate the controversy surrounding the DTP (Diphtheria Tetanus Pertussis) vaccine.
6. Students will apply their investigative data to a discussion on the bioethics of the DTP vaccine.

MATERIALS

reference books on bacterial or viral diseases
access to local clinic or doctor's offices
informational sheets on childhood vaccinations (available at health clinics)
disease information form (Figure 1)
self-devised or standard health form (Figure 2)
decision making model (Figure 3)

PROCEDURE

ORAL PRESENTATIONS

1. Students choose a disease to research and write a report on (I number a list of diseases and have each student choose a number). Each student then presents a brief oral summary of his/her disease, including the cause, acquisition, symptoms and cure and/or treatment. The other students fill in this information on photocopied forms (Figure 1) that provide space for all categories mentioned. Have students keep these forms in a booklet that can later serve as a quick reference guide.
2. This guide also should include a page devoted to the DTP and polio vaccinations that, as parents, they must take their children to get. Have students visit a local clinic or doctor's office to ascertain:
   - age requirements
   - methods of administration
   - possible side effects and their treatment

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Health Forms

3. A standard public school health form is suitable for students to use to list all diseases and/or vaccinations. The teacher can also devise a form using other health forms as a guide (see Figure 2).
4. Give each student a copy of the form and explain its contents. Also explain the importance of knowing one's health record. Parents become involved through their discussion of the student's health record with him/her. Allow students to visit the school nurse's office to fill in missing information if needed.
5. Don't collect or grade these forms as they are quite personal, but encourage students to get their parent or parents' confirmation on the forms when complete. These forms then should become part of the student's personal file to be used on school and job applications and on health record forms when visiting a new doctor.
6. Have students research DTP and the controversy surrounding the vaccine to demonstrate awareness of the issue. Use this as a launching point for a discussion of bioethics.

Classroom Forum

7. Have students conduct a classroom forum on bioethics. Students could debate the pros and cons of getting a DTP vaccine, with one half the class defending the idea and the other refuting it.
8. An alternative would be to have them individually complete a decision-making model. Figure 3 is suitable for addressing the question "What ought I do when my child is due for the DTP vaccine, yet I am aware of the dangers associated with the vaccine?" The form should include several steps:
   - the question
   - brainstormed solutions to the problem
   - a list of values that support the self-determined best solution
   - a review of the consequences of choosing that solution

Summing Up

The relevance of biology is inherent in the study of the Monerans. The report, the health form, the ethical decision making and the debate on the DTP vaccine can help students understand the role that bacteria play in their lives. A fun way to end the unit is by having a party at which the class makes and eats yogurt.

DISEASE NAME: _____

CAUSE (bacteria or virus): _____

ACQUISITION:

SYMPTOMS 1. _____

2. _____

3. _____

4. _____

5. _____

CURE/TREATMENT:

SPECIAL CHARACTERISTICS:

_____

DISEASE NAME: _____

CAUSE (bacteria or virus): _____

ACQUISITION:

SYMPTOMS 1. _____

2. _____

3. _____

4. _____

5. _____

CURE/TREATMENT:

SPECIAL CHARACTERISTICS:

_____

Figure 1

PERSONAL HEALTH RECORD OF _____

(Name)

Check the box either NO or YES for each condition listed below.
Give the dates concerning every disease or condition checked YES.

	NO	YES	DATES
Chicken pox			
Measles			
Mumps			
Poliomyelitis			
Rheumatic fever			
Rubella			
Asthma			
Diabetes Mellitus			
Hepatitis			
Seizure disorder			
Tuberculosis			

VACCINATION/IMMUNIZATION RECORD

Tuberculosis			
Measles			
Mumps			
Rubella			
Cholera			
Yellow Fever			

	NO	YES	DATE OF 1st	DATE OF 2nd	DATE OF 3rd	BOOSTER
Polio						
Diphtheria						
Pertussis						
Tetanus						
Typhoid						

Figure 2

Bioethical Decision-Making Model*

I. State the bioethical problem. State problem as an "ought to do" question (e.g. "What ought I do when. . . ")

II. List possible alternative actions or solutions to the problem, even if you don't agree with some (five is the minimum).

Ranking	Solutions
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

III. Rank these alternatives in order of preference by placing numbers beside them. For example, place #1 beside the first choice, #2 beside the second, etc. (Rank them from the one (#1) with which your values most agree to the one (#?) with which your values agree least.

IV. Take your #1 solution and list at least five values you hold that cause you to rank it as #1.

"I" Value	Personal Meaning of Value Word
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

**Adapted from the Jon R. Hendrix/Pat Somers Model, Ball State University*

Figure 3

V. Now take your solution and describe the consequences you think it would have. Do any five of the long term and short term consequences.

How Would This Solution Affect My:	Short Term	Long Term
Money		
Time		
Personal relationships		
Family		
Friends		
Psychological self		
Community		
Country		

VI. Place a "+" beside each consequence you hold as "good" and a "-" beside each one you hold as "bad."

VII. Are there any real "bad" consequences that you couldn't live with? If so, try another solution or modify your solution.

VIII. List three reasons why others might not agree with your solution to the problem.

1.

2.

3.

IX. Restate your solution and then place a *confidence* or *conviction* measure on it by X'ing the number on the confidence scale below.

My solution _____

_____

_____

I can live with my solution — I cannot live with my solution

1 — 2 — 3 — 4

very — not very

CHAPTER 2. STUDENT PROJECTS

Data Collection/Analysis Over Time

INTRODUCTION

Keeping data for each year that a lab is used is a good way to impress upon students the importance of keeping track of previous studies. Having them include these data in their lab reports stresses to them that their work is important and will be used long after they have left the class. It reminds students that scientists do not work in isolation but work together collecting and sharing data.

OBJECTIVES

1. Provides the opportunity to handle data over several years.
2. Illustrates the value of having a lot of data (large sample).
3. Given the formula for chi-square and experimental data, students:
   a) calculate the chi-square value.
   b) determine the times in 100 that the same value might be produced by chance alone.
   c) determine if any deviation is significant.

MATERIALS

You may choose your own labs for data collection. I have used:

Lab 13-A (tobacco laboratory investigation), BSCS Blue version *Molecules to Man* (1980), D.C. Heath and Co.

Lab 1 (potato investigation), BSCS Blue version *Molecules to Man* (1983), Houghton Mifflin [Lab 1-A in BSCS Blue version *Molecules to Man* (1973), Houghton Mifflin.]

PROCEDURE

The tobacco and potato investigations are not unique; they are two of many examples of activities requiring students to collect data. What is unique is that by collecting and keeping the data over a period of years the teacher can easily illustrate the value of extensive data (large sample size).

The data sample of an individual student or team usually is small. Any errors will be greatly magnified. Errors in measuring, recording, etc. are less likely to have a significant impact if the sample size is made larger; this can be accomplished by pooling the data with other members or teams in the class. A much larger sample can be obtained by including data from other classes doing the activity that same year as well as classes that completed the activity in previous years.

It has been my experience that students show more interest and enthusiasm when they can compare their results with those obtained by their peers and possibly by older siblings who completed the activity in previous years.

Students need to be reminded that hypothesis and theories are based on repeated experimentation over a long period of time. They appreciate knowing that they don't have to repeat the same activity over and over again in order to obtain a large data sample.

OBTA
CALIFORNIA, 1985
Stan V. Ogren
Menlo-Atherton High School
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Atherton, CA 94027

Figure 1a. Average weight change of potato cores in percent.

Period	Core A	Core B	Core C
1. c-1	+12	-6	-22
1. c-3	+13	-5	-19
2. c-1	+12	-5	-22
2. c-3	+13	-5	-20
3. c-1	+15	-3	-21
3. c-3	+11	-6	-20
4. c-1	+11	-3	-17
6. c-3	+6	-6	-17
Total	+93	-39	-158
Average	+12	-5	-20

Figure 1b. Average weight change of potato cores in percent for 1969-1990.

Year	Core A	Core B	Core C
1969	+13	-1	-21
1970	+10	-3	-21
1971	+13	-4	-20
1972	+10	-3	-20
1973	+12	-4	-20
1974	+11	-2	-19
1975	+11	-7	-23
1976	+11	-3	-19
1977	+12	-8	-19
1978	+10	-7	-21
1979	+13	-2	-19
1980	+10	-3	-21
1981	+13	-4	-22
1982	+12	-2	-19
1983	+10	-4	-18
1984	+12	-3	-19
1985	+10	-4	-20
1986	+10	-10	-25
1987	+11	-4	-20
1988	+10	-4	-18
1989	+11	-3	-19
1990	+12	-5	-20

CHAPTER 2. STUDENT PROJECTS

Academic Biology Genetics Report

INTRODUCTION

Students work in pairs and pretend they are the parents of a child born with a genetic defect. They will pick from a container called a Sex Pot for the child's sex and from a Mating Bureau for the child's phenotype. Students keep a journal as though the child was real, describing their feelings, the cause of the defect, the symptoms that are observed and any treatments or cures that are available to them. Students must have at least seven entries in their journals.

OBJECTIVES

1. Students will learn about human genetic defects.
2. Students' affective domain will be sensitized to human genetic abnormalities. This is one of several sensitizing activities done in the unit, i.e. videos, visits, filmstrips.

MATERIALS

pamphlets placed in file folders by topic
  Collect from:
  March of Dimes
  foundations for individual defects, such as the Cystic Fibrosis Foundation
  magazine articles brought in by teachers and students
  (Some students send for their own materials.)
strips of paper
pen or pencil
scissors
2 containers (1 for Mating Bureau Results, the other to serve as Sex Pot)

PROCEDURE

1. Students first collect information from the pamphlets and from the library. Since some defects are more difficult to research than others, this will be taken into account when the journals are graded.
2. Fill in due dates and distribute the following information:
   - Journals are graded with the following weights:
     Completeness (15 points)
     Accuracy of data (15 points)
     Demonstration of understanding (15 points)
     Creativity in use of scientific information (15 points)
   - Due Dates: _____
     Notes: _____
     Completed Paper: (60 points)
3. Students select a partner (usually of the opposite sex, but this is not important if you have more of one sex than the other in class) with which to work on a journal. Occasionally students wish to be "single parents." The journal grade is given to each student who helped with its production.
4. Students are assigned reports on a random basis. List the genetic defects in Figure 1 on strips of paper and

OBTA
MAINE, 1983
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place them in a container labeled "Mating Bureau Results." After students draw a strip to serve as the basis for their report, they go to a "Sex Pot" and select a strip that tells them the sex of their child. (In some cases the sex has already been determined.)

Summing Up

After the lab, ask students if there is anything they want to discuss with the class. This can include their feelings or information. Some classes will be more eager for a discussion than others.

Figure 1

Genetic Diseases

1. You have a child with cystic fibrosis.
2. You have a child with phenylketonuria (PKU).
3. You have a child with sickle cell anemia.
4. You have a child with Down's syndrome.
5. You have a child with galactosemia.
6. You have a child with thalassemias.
7. You have a color-blind child.
8. You have a boy with Duchenne muscular dystrophy.
9. You have a child with spina bifida.
10. You have a boy with hemophilia.
11. You have twins that you suspect will have Huntington's chorea.
12. You have a child with Tay-Sachs disease.
13. You have a girl with Turner's syndrome.
14. You have a boy with Klinefelter's syndrome.
15. You have a boy with albinism.
16. You have a child with diabetes mellitus.
17. Your son has been diagnosed as having an XYY chromosome or "Super Male" combination.

CHAPTER 3. NEWSLETTERS

Science Newsletters

INTRODUCTION

Have you worked hard to bring about a superior instructional program that you think is really worthwhile? Keep interested parties informed of your successes and get students' interest by producing a newsletter. The periodic distribution of a science newsletter to students, parents and administrators that describes program activities and successes can promote a major turnaround in the recognition of students' efforts and bring community and school support for your program.

OBJECTIVES

1. To get students involved in science communication skills and processes.
2. To accurately inform interested parties of your students' efforts, achievements and activities.
3. To engender broad parental, administrative and community support for your science programs.

MATERIALS

IBM-compatible or Apple personal computer
near letter-quality dot matrix printer
copy machine
word processing software
desktop publishing program that provides a newsletter format

PROCEDURE

STUDENT SCIENCE WRITERS

1. Each semester, assign students who wish to be reporters for the newsletter specific articles or topics and deadlines (in lieu of other science writing assignments) by the teacher (who is editor-in-chief). Consider continuing columns which appear in each issue; I use "Taking Note," which features science students' accomplishments; "Department Events," happenings in the science department; "Concepts Learned," recent instructional topics; "Column of Distinctions," individual student or faculty events or achievements and "Science Teacher Feature," a biographical or personal sketch. Also include feature and topic articles.
2. Bring the team of student writers together with the science faculty early in the grading period to brainstorm for ideas. The ideas are discussed, expanded, outlined and assigned. Students seem to come up with their best ideas during these editorial sessions.
3. Have students enter the text of their articles on the science department computer to be spell-checked and edited , then laid out. I use an IBM PC and an inexpensive layout program, Spinnaker's Word Publisher. It provides a newsletter format; I add titles and text. You may want to have a contest to design a logo and come up with a name for the newsletter.
4. Remember that it is important to

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OHIO, 1988
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maintain strong faculty editorial control. Students become exuberant, but may overlook simple spelling, grammar and accuracy. Be prepared to return article drafts for appropriate revisions and corrections.

5. The one or two page sheets are copied and sent home with students to all parents. Be sure to send copies to the school's administrators, guidance counselors and superintendent. Copies with an explanatory cover letter are sent to supporting or interested citizens and groups. Everyone with any possible interest, including local media, should receive a copy.
6. This is an excellent way to keep people apprised of what's been happening in the biology classes. Articles that explain major topics learned by students are especially useful. Administrators and parents may not know what happens when a student peers down into a microscope. A description of amoeboid movement as seen by a student in a recent lesson becomes meaningful. How the *Amoeba* came to the school from a supply house, paid for by the lab fee, is explained. And, students get a sense of what it's like to write about science for non-scientists.

Equipment Donations

1. Consider sending copies of your newsletter to local industries and medical facilities with cover letters introducing your educational objectives and activities. I have specifically asked for donations of used or obsolete scientific equipment. In the last four years our department has received:
   - 3 spectrophotometers
   - 2 constant-temperature water baths
   - 1 automatic autoclave
   - several constant-temperature test tube blocks
   - 1 gas chromatograph
   - several hundred pieces of lab glassware
   - numerous miscellaneous lab items

   We always send a thank you letter with an estimate of the present worth of the donated equipment so the donor can make a tax deduction.

Help for Student Research

1. Devote a section of the newsletter to describing student research projects and any scholarships and awards they have won. Send the newsletter with a letter to local industries and service clubs and solicit small contributions to further this activity. In addition to gaining recognition for their work, students can get financial support for consumables and for fees and transportation to competitions, symposia and professional science society meetings.

Perkins Science Newsletter

Events, Happenings, and News from the Perkins High School Science Department

Volume 4, Number 3 26 March 1991

PERKINS STUDENT GETS ATTENTION OF NOBEL CHEMIST

by
Gargi Narain

Students of Chemistry Teacher Carol Palmer know that her favorite chemist is Dr. Linus Pauling, winner of the Nobel Prize for Chemistry for his research in chemical bonding and protein structure. He is a double Nobel Laureate with an additional Nobel Peace Prize recognizing his work to halt atmospheric testing of atomic weapons.

With an understanding of Mrs. Palmer's interest in the California scientist, Jennifer Payne, a junior in Mrs. Palmer's Chemistry I class, set out make some personal contacts. Jennifer learned that Dr. Pauling works at his own research center, the Linus Pauling Institute of Science and Medicine at Palo Alto.

To get the address of the Institute, Jennifer called the California Institute of Technology (Cal Tech) in Pasadena. The librarians at Cal Tech were able to find the address and phone number of the Pauling Institute. Jennifer was then able to contact Dr. Pauling's secretary. After a short conversation the secretary determined that Jennifer represented a class of hard working, productive chemistry students, and recognizing Dr. Pauling's concerns regarding American science education, had two autographed pictures of Dr. Pauling sent to Jennifer.

Mrs. Palmer now has an autographed picture of Dr. Pauling for her classroom and one for her home study. The scientific community ranks Dr. Pauling on a par with Albert Einstein in his effects on the progress of modern science. We are fortunate to have his personal recognition of our chemistry program.

Dr. Pauling just celebrated his 90th birthday.

KEEPING IN TOUCH WITH PARENTS

by
Joann Roy

An important aspect of the Perkins Science Department is its attempts to keep parents informed of their student's academic performance.

For instance, several teachers use the Report to Parents (RTP), an interim grade report that goes home with each student three or four times during the grading period. It provides parents with the student's current grade score average and a plot of the student's previous grades so showing the student's grade trend.

The RTP must be returned to the science teacher with a parent's signature verifying that the parent is aware of his or her child's performance. If the RTP does not suffice, and the parent feels that his or her child is having trouble, the faculty of the science department are will meet with parents during conference periods, or at other convenient times. Concerned parents should call 625-1252 to arrange for a meeting.

PERKINS STUDENTS COMPLETE RESEARCH IN INDUSTRIAL LABS

by
Joann Roy

An article in the last issue of this newsletter reported the progress of several students conducting research in laboratories outside of Perkins High School. These students have completed their work and reported several interesting findings.

An example of the newsletter produced by the Perkins High School science department.

CHAPTER 3. NEWSLETTERS

Surveying Former Students

INTRODUCTION

Wouldn't it be nice to find out what has happened to your students years after they've flown the nest? But what a chore! Finding all those addresses. Writing all those letters. Labeling all those envelopes. But it is data like these that help tell us how successful we are at preparing our students.

A good idea, but how to do it? Enlist your computer and an integrated software program such as Appleworks or Microsoft Works. You will use the data base portion and the word processing segment.

OBJECTIVES

1. To keep in contact with former students via follow-up surveys and newsletters.
2. To provide long term summative course evaluation.
3. To get students interested in science writing and research projects.

MATERIALS

Apple computer
printer
copy machine
desktop publishing software such as Publish It!
integrated software program such as Appleworks or Microsoft Works (you'll use the data base portion and the word processing segment)

PROCEDURE

1. Start now. If you don't already have the information, your registrar probably can give you the names and addresses of former students. Begin a "get acquainted" form that students fill out at the beginning of the year. (It's a good chance to also find out about interests and hobbies, as well.)
2. Begin a data base with the following fields:
   First name
   Last name
   Street
   City
   State
   Zip
   Year
   Course
3. Enlist students' help in writing a newsletter that contains articles about what is happening in the science program. I use an Apple computer and Publish It! software; the newsletter is run off on the school's copier.
4. Have the computer select from your data base those students who have already graduated and print out the names and addresses on pin-feed mailing labels.
5. Send these students the newsletter along with a follow-up questionnaire about what they have been doing since

OBTA
ARIZONA, 1982
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graduation. Tell them they'll receive future newsletters if they return the questionnaire. My principals have always encouraged me to do this type of follow up and have always paid the postage to mail it. I send the copies to our mail room to be run through a postage machine. Ours are sent first class, but a cheaper way may be possible.

6. Sit back and tabulate your results. Or, better yet, have students do the tabulation. You might also ask them to help design the questionnaire. You'll find out what your students found useful in your course, which will help you with curriculum improvements and provide data for a long term study of the course. Students will get to try science writing and will participate in a research project. What's more, they know that after they graduate they'll continue participating in the project–as subjects.
7. Some questions you might consider including in your survey are listed in Figure 1.
8. Share your data with the people who are evaluating you and your program. Keep up to date and do a mailing each year; the results will amaze you. Often students will put in interesting anecdotal information along with the questionnaire that makes excellent reading.

Figure 1

1. How have you applied the biology course in your adult life?
   a) Hobbies (i.e. gardening, birding, photography, etc.)

2. Rank the following themes/concepts as to how meaningful they have been to your life now (1 = most meaningful, 8 = least meaningful):
   human structure and function
   cell theory
   evolution
   energy transformation in living systems
   genetic continuity
   ecological principles
   diversity of life
   classification systems

3. Career application
   a) Have you taken a biology/medical course in college?
      If yes, how many?
   b) Have you pursued a biomedical career?
   c) Does your current employment apply biological concepts (farming, landscaping, florist, etc.)?
      Elaborate.

Buena Bugle

January, 1991

A New School Building

The next time you visit your alma mater it may no longer be here. Fact is Buena High School will still be around but it will be a brand new facility. The new building, constructed to house 2500 students, will be located just east of the Sierra Vista branch of Cochise College.

The new school will boast a state-of-the-art theater complex, complete with rotating floor. Such a theater will serve the community as much-needed a cultural center.

In case you are able to drop in some time, the science department will be located on the second floor. You will have to check in with the office before you visit since the school will be closed campus and gates will be locked and guarded during school hours.

Projected date of completion: January, 1992.

How to Keep Getting This News Letter

If you like reading about your alma mater and the science department and if you want to remain on the mailing list, simply take a minute NOW to fill out and return the attached questionnaire. Your help will be appreciated and will provide useful information about the successes and failures of the program that will allow us to improve.

Many thanks for your help.

Ecology Class Return with Added Strength

After a two year absence the Advanced Ecology Class has returned to Buena. The class, last taught in 1988, was not run due to too few people signing up. This year it ran with two sections - a total of 58 students! Next year it will run again with 64 students signed up.

The reason for the hiatus is unclear but a renewed interest in the environment may be its chief stimulus.

As usual the course's hallmarks are numerous field trips and (also numerous) term projects. New to the course this year is a unit on toxicology which includes environmental and physiological components. Also new is a trip to the power plant that supplies electricity to the area.

Big festivities are planned for Earth Day and the Ecology Class hopes to participate.

Health Career Sciences Alive and Well at Buena

The Health Career Sciences course (formerly Health Occupations) continues to be one of the most active in the state. Two sections of the beginning course are in place this year as well as the advanced two hour block in which students spend two hours a day at local clinics and hospitals.

Of course many of the students from this class are members of the MedStart club. The major activities of the club center around an annual blood drive for the Red Cross and drug awareness for elementary students at the local schools.

Our drive, coupled with the student council's drive has given Buena the trophy for the most usable units of blood produced by a high school in southern Arizona four of the last five years. (We lost to Nogales by one unit two years ago.)

A copy of the *Buena Bugle*, produced by Buena High School's science department.